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Width (metres)	4	4,50	5	6	7
Depth (metres)	1,50	1,50	1,80	1,80	1,80
Draft app. (metres)	0,65	0,70	0,80	0,80	0,75
Max. cutter depth (metres)	3,50	5	6	7	8
Max. distance of discharge (metres)	250	500	750	900	1000
Max. height of discharge at max. distance (metres)	3	3	3	3	3
Mixture production at max. height and distance cbm/h.	300	400	620	900	1200

STANDARD SIZES	ZC 17½	ZC 20	ZC 25	ZC 30	ZC 35
*Percentage of soil in mixture	10-20	10-20	10-20	10-20	10-20
Soil production at max. height and distance cbm/h.	30-60	40-80	62-124	90-180	120-240
Diameter suction pipe (cm.)	20	25	30	35	40
Diameter discharge pipe (cm.)	17,5	20	25	30	35
Total Diesel power H.P.	85	155	259	374	487

** Note that the percentage of soil in the mixture depends on the nature of the soil and consequently the soil production will vary between the given figures.*

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Editorial Notes

The Port of Aqaba

In this issue we print the second of three articles describing the development of Aqaba as an ocean port designed to give the Hashemite Kingdom of Jordan some measure of economic independence. The first, appearing in our July issue, dealt with the historical background of this venture, but only since 1952, and was written generally in terms of economics, but the train of events which has led to Jordan, and its dynasty so long devoted to the cause of Arab unity, being estranged among its neighbours and compelled to seek an independent outlet through its 5-mile sea frontage at the head of the gulf of Aqaba is not a story which can be told in economic terms at all. It is a product of the conflicts and confusions and rival claims to suzerainty by which the Arab world has been afflicted almost without intermission since the disintegration of the Ottoman Empire in 1918.

As a result of the hostilities which followed the abandonment of the Palestine mandate by Britain and the proclamation of the Republic of Israel in 1948, the new Kingdom of Jordan (embracing the pre-war Amirate of Transjordan) found herself in possession of nearly half of pre-war Palestine but without the means to sustain the added population. Egypt lost most of the Negev and the Israelis established themselves on the Gulf—where, by reason of the continued closing of the Suez Canal to their ships and cargoes, they are now engaged in developing an ocean terminal in close proximity to that at Aqaba. Thus, this deep, 100-mile long inlet, so closely over-looked at the entrance by the United Arab Republic and Saudi Arabia, has two national ports at its head whose future must depend on its recognition as an international waterway.

As for the Port of Aqaba, technically its installations are unremarkable. In truth, their selection and siting admitted no alternatives and no particular difficulties presented themselves although the great depth of water may do so if further extensions are contemplated. Some anxiety was felt as to the possibility of ranging of vessels at the quayside for southerly winds are apt to pile up considerable wave action in the long fetch of the Gulf, but such winds are infrequent and of short duration and the orientation of the wharf will minimise the effect on vessels alongside. The opening-up of a wet basin would scarcely have been appropriate or economic although the suggestion appears to have been canvassed at one time. The deep water and steeply shelving seabed limits the mooring area and some concern might be felt for vessels at anchorage in bad weather conditions but nevertheless the holding appears to be good.

The interest in the project lies in the fact that, unlike most ports which have grown up around a slowly developing established trade, Aqaba is an entirely new venture and the rate at which its traffic has increased, where little or none formerly existed, with exiguous land communications and in most unpromising circumstances, is quite remarkable.

The traffic in general cargo is all one-way, which is not particularly attractive to the liner trade. Exports are wholly made up of raw phosphates in bulk, which presumably move in whole cargoes in chartered vessels. The prospects of this trade increasing, to India and the East, are good, and the facilities for it may need to be enlarged. This is rather a question of improving the land transport or increasing stock-piling, or both, and it seems rather a pity that a transporter system commanding all hatches of a ship was not installed in the first place, for vessels dislike the constant hauling which present arrangements necessitate and the basic capacity of the loading plant would otherwise seem to be sufficient for all reasonable needs.

It does not appear that alongside facilities for general cargo have so far contributed very much to the total cargo handled, the great majority of which has been transferred by lighter. Much of the cargo is easy, in bags and bales well suited to lighter-working. In such circumstances it is essential to devise a tariff structure which will encourage the optimum use of costly alongside facilities. Too often great pressure is exerted on the Port Authority to extend deep water quayage which is then never fully employed. Striking a proper balance in a "combined" port in the face of established vested interest is a problem which has often proved difficult to solve.

Mooring Dolphins at Kitimat

A good deal of attention has been directed in recent years to the design of flexible berthing platforms and dolphins composed of clumps of piles which rely for their stability not on combined bearing and uplift when braced together but on the elasticity of the piles themselves considered as vertical cantilevers securely anchored into the seabed material. Obviously, conditions which allow sufficient penetration in fairly homogeneous ground to provide the requisite degree of fixation are not often met with but in favourable circumstances the method supplies a means of withstanding berthing impact in a simple and effective manner and has been employed with considerable success for the mooring of tankers which do not require elaborate or continuous wharves for their accommodation. A good example occurs at Pulau Bukom, Singapore, where tanker berths take the form of a curtain wall composed of broad-flanged Peine joists driven as piles with a slight forward rake and capped by a continuous reinforced concrete beam which in the uncompressed position is some 18-in. away from the T-head of the pipe-supporting jetty. In this arrangement the cantilever effect is obtained in two planes at right angles.

The work carried out by Alcan at Kitimat, British Columbia, which is described in the article we print elsewhere in this issue is more orthodox in form though it relies on the same general cantilever principle, but here the piles consist of 30-in. diameter steel tubes with wall thickness of ½-in. and ¾-in. driven vertically

with closed ends, each dolphin being made up of a centre pile with six others radiating on a 15-ft. diameter pitch circle. The design was largely influenced by technical articles describing similar flexible dolphin installations at the Port of Amsterdam which were published in this Journal in June and July, 1954. At Kitimat preliminary boreholes were sunk to ascertain the stratification of the underlying soils from which the simplified foundation theory, with certain assumptions, indicated that at least 40-ft. of penetration was required and much of the interest in the project naturally centres around the method of driving and the behaviour of closed-end tubes of large diameter when driven to this depth in non-cohesive material. In this particular instance axial bearing capacity is of little moment. The problem was to obtain adequate penetration in the hope and expectation that after such heavy disturbance the strata would reform and supply the necessary firm anchorage. In the course of driving, however, much information was obtained which adds to our general knowledge of the action of bearing piles. A great deal has been written in the past on piling formulæ and many attempts have been made to find a reliable prediction of bearing capacity and toe resistance from the data obtained during driving. There is still insufficient experimental data on which to base any realistic treatment for this is essentially a practical problem which must be investigated at full scale.

Having concluded that it makes little difference whether large diameter tubes are driven with open or with closed ends, (which is probably correct) there seemed to be no reason why the hammer should not be contained within the tube and its energy applied directly at the toe of the pile. In practice the open toe was sealed by a 5-ft. plug of concrete, a thick layer of sand and crushed stone taking the place of the more usual packing so that much of the force of the blow was absorbed in compaction and elastic compression of this material. The driving energy curves seem to confirm recent pile driving theories (particularly where the bed material is granular and displacement is large) that during driving the pile makes for itself a hole so that, for all practical purposes, resistance to motion is concentrated at the toe and frictional resistance cannot begin to operate until stratification of the disturbed soil has sensibly been restored. Failure to distinguish between the two component forces by which a pile is supported may account for much of the inconsistency which accompanies the use of existing dynamic pile driving formulæ.

The complex forces resulting from oblique impact have necessarily been very much idealised in the calculations but experience of berthing under a variety of conditions show that deflections have been in fair agreement with prediction. It is not quite understood why the tubular piles are described as fabricated from high tensile steel since the material seems to have the low yield-point of very mild, almost ship-quality, steel which would appear quite suitable for such a purpose. No information is given about tidal sets but it is presumed that the direction follows the course of the valley and coincides with that of the prevailing winds. It should be easy, therefore, for a vessel to stem the tide and be laid close to the line of the dolphins for final winching in but there is always the chance of taking a sheer and bumping heavily during these operations.

Development Plans for Indian Ports

According to reports in the Indian press, finance for the development of major ports in India during the third Five-Year Plan has been tentatively fixed at Rs. 750 million (£56 mn.). During this period emphasis will be on the early completion of schemes already in hand for maintaining and improving the existing services. Funds (in millions of Rupees) will be allotted as follows: Calcutta (285), Bombay (256), Madras (73), Cochin (17), Vishakapatnam (63) and Kandla (43).

As regards Bombay, the main items of expenditure include an extensive dock modernisation scheme, the dredging of the main harbour channel, the construction of a new passenger terminal, housing, dredgers, tugs, miscellaneous port equipment and the electrification of cranes in the Alexandra Docks. So far as the minor ports are concerned, Rs. 100 mn. have been allotted in the third plan period, as against Rs. 50 mn. allocated for the second Five Year Plan.

The Intermediate Ports Development Committee appointed by the Government has recommended the development of Tuticorin (Madras) and Mangalore (Mysore) as first priority works. Paradip (Orissa) and Porbandar (Gujerati) have been given second priority. The Committee also recommended development works for a further 21 intermediate ports round India's extensive coastline, including a few minor ports which, in its opinion, should be developed as intermediate ports.

The Committee was asked to select suitable intermediate ports for intensive development in order of priority and to determine the extent of development required at these ports, " taking into account the broad national considerations as well as the regional requirements, engineering aspects and traffic potential of the hinterland and the transport cost."

In their report, the Committee called attention to the need for developing additional capacity at ports to cope with the growing volume of cargo to be handled, particularly in view of the expected increase in the export of iron ore. They estimated that iron ore exports from India will rise to 15 mn. tons a year by 1966-7 as against 2,800,000 tons at present. In their view, the developments recommended above should be sufficient to create this capacity.

Effluent and Water Treatment Exhibition

The problem of effective effluent disposal and the importance of preventing river pollution is receiving increasing attention by industry. It is therefore appropriate that an Exhibition and Convention should be planned at which these problems can be discussed.

The first Effluent and Water Treatment Exhibition is to be held next October at the Seymour Hall, London. A wide range of equipment, plant, and techniques will be exhibited and, simultaneously, a convention will be held with the co-operation of a number of societies and institutions specialising in effluent and wated treatment problems, at which papers will be given by leading experts. The subjects will include: Analysis techniques; biological effluent treatment; boiler feed waters; composting treatment; development of filtration and water treatment plant; discussion of Armour Committee Report; electro-precipitation of industrial mists and dusts; fluoridation; manufacturers' problems in disposing of effluents and trade wastes; problems of design in effluent system plant; pumping; river pollution; sewage disposal without main drainage; treatment of radio-active waste materials; waste water recovery; water softening.

Full details can be obtained from the Organiser, the First Effluent and Water Treatment Exhibition, 140 Cromwell Road, London, S.W.7.

Traffic on the St. Lawrence Seaway

As was forecast, there has been a considerable increase in the tonnage of cargo carried on the St. Lawrence Seaway in the first three months of the 1960 season compared with the corresponding period last year. The increase is especially marked in bulk cargoes, despite a decline in the number of transits.

In the Montreal-Lake Ontario section, the volume of bulk cargoes increased from 1,768,101 tons to 2,703,483 tons in the up direction and from 3,024,827 tons to 3,298,914 tons in the down direction. The figures for the Welland Canal section are just as noteworthy. Bulk cargoes in the up direction totalled 2,787,053 (1,899,947) tons and downwards 7,037,111 (5,601,696) tons.

The Port of Aqaba, Jordan

Review of Development during the last Decade

(Specially Contributed)

(continued from page 94)

II. Details of Construction Works

Detailed Plans and Tenders

Studies on the site were put in hand soon after the consulting engineers' preliminary report had been examined by the Government. Borings of the sea bed were carried out on the selected site, south of the village, under supervision of the consultants in October 1953—January 1954. They showed that in this part of the Bay the sea bed was mostly fine loose sand. No conglomerates, no coral and no rocks were found in the sea bed, but layers of hard conglomerates were located on and near the shore.

Preparation of detailed plans, specifications and tender documents for civil engineering works proceeded during 1954 and 1955 when the policy decisions were being reached. Invitations for tenders were issued to a large number of selected international contractors in March 1956 for submission on August 1, 1956. Because of unsettled conditions in the Middle East in July, which lead to the Suez Canal crisis, very few tenders were received. The tender of the West German firm, Zublin and Co., in the total amount of nearly £1¾ million was the lowest and was accepted in September 1956. Supervision of works was later entrusted to Rendel, Palmer and Tritton. Actual work on the site could not be started till June 1957, after reopening of the Suez Canal.

The phosphate handling plant had been excluded from the contract and was not covered by consultants' specifications. The facilities suggested by the consultants in their preliminary report were of a simple type and cheap from the point of view of capital expenditure and consisted of open storage of phosphates by retaining walls, mobile grab cranes, portable belt conveyors, and bulldozers for piling and for feeding a permanent shipping conveyor. However after receiving the consultants' report the long term prospects appeared very favourable both for the production and for the export of Jordanian high-grade phosphates; the Aqaba Port Authority was therefore anxious to provide more modern and efficient loading facilities. A separate tender was therefore issued in November 1953 for a more elaborate and fully mechanised plant. Several British, German, American and French manufacturers, specialised in handling equipment for bulk cargoes, were invited to submit their own detailed projects on the basis of a general description prepared by the U.N. port expert. Upon selection of three best offers, advantages and possible improvements of the proposed schemes were examined and discussed at length with the consulting engineers and with the manufacturers. A final award was made to Simon Handling Engineers of Stockport, Manchester, who undertook the manufacture and erection of a complete storage and loading plant, at a total cost of about £300,000.

Specifications for an electric power plant of 1350 KVA were prepared by Rendel, Palmer and Tritton in 1957 and the contract was awarded in May 1958 to the successful tenderer, Brush Electric of England. All the above works were completed in 1959, as shown on the plan (Fig. 3—page 93) and on the photograph (Fig. 4—page 94) in last month's issue.

General Cargo Berth

For the general cargo berth, a 160 metres long marginal wharf has been built having a depth of water of 10 metres at low water level. Difference between highest and lowest water is only about 1 metre in Aqaba. A very strong retaining wall of steel sheet piling was first driven, approximately on a 4 to 5 metres depth line, using profile Fordingham No. 5 in lengths of 27 metres. The level of the shore has been raised by extensive rubble filling to about 2.40 metres above sea level.

To reach the line of natural depth of water of 10 metres, a reinforced concrete platform was built on steel box piles, 24 to 27 metres long. The piles were Krupp, profile No. 34. They were provided with cast iron shoes and after driving were filled with concrete. The width of platform from the steel sheet wall to the water edge is 18 metres.

A large transit shed, 108 metres long and 60 metres wide has been built behind the wharf. The shed is divided into three spans of 20 metres each. Stanchions and roof trusses are of steel, roof covering is in corrugated asbestos sheeting. The two water side rows of columns are supported by steel piles driven 10 to 12 metres into the soil. A cross section of the wharf is shown on the following page (Fig. 5).

Originally, the shed was planned with two spans of 20 metres, giving a total width of 40 metres. However, experience of previous years had shown that imported cargoes must stay in Aqaba for a longer period than would be the case in an average port located near the main centres of consumption. Because of the long distance to Amman, the limited number of available trucks, and of various formalities connected with custom clearance, import permits and bank credits; sugar, grain and general cargo often remain in the port area for one month or more. Shortage of covered space resulted several times in serious damage by rain to cargo stored in the open, especially to sugar. Under impact of the greatly increased traffic, the port authority approved therefore, in September 1958, the port expert's proposal to increase the width of the new transit shed to 60 metres by adding a third span in order to avoid similar losses in the future.

The width of the quay apron in front of the shed was originally planned at 20 metres. However, the consultants considered that the shed should be 10 metres further away from the waterfront so as to avoid excessive pressure on the soil near the top of the steep slope of the sea bottom; the actual width of the apron had to be increased, rather reluctantly, to 30 metres. In order to facilitate cargo handling on this wide apron, the port authority have decided to erect on the wharf electric gantry cranes, while previously the intention had been to use ships' gear and mobile equipment on land. Offers for 3 ton cranes have been invited, but no order has been placed as yet.

The floor of the shed on the water side is on the level of the wharf. At the back there is a wide loading platform, 1.10 m. above the level of the road. Two open storage areas have been arranged in the rear, one asphalted, another gravelled. A special enclosure for animals, an inflammable goods store, a shelter for mobile cranes, a weighbridge, canteens for port employees and workmen, well paved roads and a wire mesh

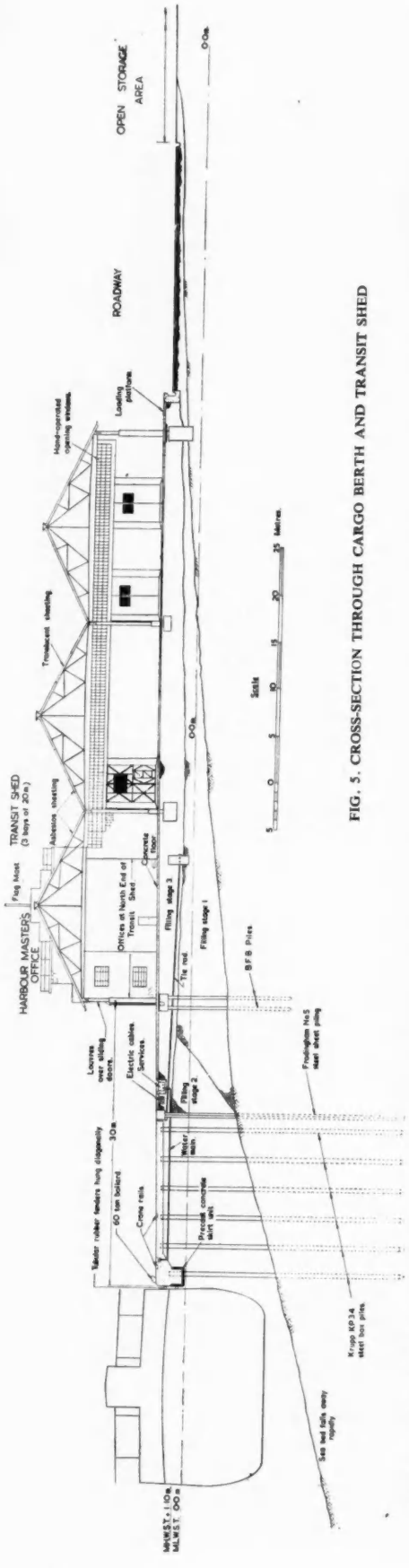


FIG. 5. CROSS-SECTION THROUGH CARGO BERTH AND TRANSIT SHED

fence, complete the installations of the general cargo berth. The illustration (Fig. 6) shows the general cargo berth and the transit shed after completion of the works.

The adjoining area of land, immediately to the North and towards the village, has been reserved for a second deep water berth for general cargo, to be built whenever the need for extension should arise. The older lighter berth near the Fisheries, will also be fully used in the future, in addition to the deep water berth. Should several ships be in port at the same time, one or sometimes two will discharge direct to the new wharf, while the remaining vessels will be handled at the anchorage through lighters as in the past. Aqaba will be a combined deep water and lighterage port.

As more than 300,000 tons of dry cargo imports have been handled in 1959 on the Lighter Wharf and in the Military Basin, without the benefit of the new deep water wharf, it can be expected that the present enlarged facilities for general cargo willl prove sufficient for some time to come. However, handling of commercial imports in the Military Basin will be probably gradually restricted. In a more distant future, the intention is to use this basin for yachts, motor boats and other pleasure craft.

Phosphate Berth

At the new deep water berth, phosphates were to be loaded on ships by belt conveyors. It was not necessary therefore to provide a continuous quay; strong dolphins, with a loading tower in the centre, have been built instead. The dolphins are placed in straight continuation of the general cargo wharf, in order to provide one uninterrupted water front. Dolphins have been built as large reinforced concrete platforms supported by 24-26 metres long steel box piles and by slightly longer raking piles, of the same type as used at the general cargo berth. The two central dolphins are of a much stronger type while the three outer ones are of a considerably smaller size. In the centre of the berths a dolphin, set slightly back supports the loading tower. Strong fenders, timber faced with rubber compression blocks have been provided for the protection of the central dolphins, and simple rubber fenders on the outer dolphins. All dolphins are connected one with another by a light gangway, while an inclined structure carries the shipping conveyor from the shore to the loading tower. The distance of the berthing face to shore is about 40 to 50 metres.

The Phosphate Loading Plant

Phosphates arrive in Aqaba by trucks, either direct from the mines in Roseifa near Amman, or from the railhead at Ras-en-Naqb. Obviously, a substantial stock must be held in Aqaba in order to assure prompt loading of vessels. Two adjoining stores, 76 metres long and 37 metres wide, have been provided in the plant, each with a capacity of over 20,000 tons of phosphates. They are covered by corrugated iron roofs, inclined both ways at 35° — the natural angle of repose of dry phosphates. The stores are parallel to shore and are located just north of the centre line of the berth.

On the other side of this line, two concrete intake hoppers for 70 tons each have been provided at a distance of 45 metres from the stores. Trucks are dumped into the hoppers with help of hydraulic dumping platforms and phosphate is brought by rising intake conveyors to an upper gallery on the centre line of each store, at a rate of 250 tons per hour. With the help of a throw-off carriage, the material is dumped into the stores. Dry phosphate should fill almost the entire cross-section of the store, by coming to a rest at an angle of 35°.

Loading of phosphates from the stores to a ship is made with help of four reclaiming conveyors and one shipping conveyor. Reclaiming conveyors are located in four tunnels under the stores. Through openings in the floors, provided with feed-on shoes, phosphate flows by gravity on the conveyors and is brought to a single ascending shipping conveyor and to the loading tower in the centre of the berth. A retractable boom extends over the ship's hold and the phosphate drops into the hold through a swivelling telescopic trunk at a rate of 500 tons per hour. The shipping conveyor is not movable and vessels must be shifted during loading operations, to bring each hold opposite the loading tower.

In order to remove from the stores any phosphate stock that would not flow by gravity, drag scrapers have been provided in each store. They are operated from enclosed cabins at the ends of the stores. Motors and winches are located outside, out of reach of phosphate dust. Inside the stores, rails have been arranged on side walls on which are travelling trolleys with cables for moving these crescent drag scrapers. No operators are normally expected to work inside the stores where dust would make manual working impossible. Dust in the tunnels is eliminated by a complete system of exhausters, phosphate from the dust being recovered by filters and brought to the shipping conveyor. The illustrations (Figs. 7 and 8) give a general view of the berth with the loading tower, and of the stores.

The actual speed of loading into a vessel has exceeded 550 tons at first trials, but allowing time necessary for trimming and for shifting the vessel, the average speed of loading will probably be in the neighbourhood of 300 tons per hour or slightly better. A Liberty ship will be able to take a

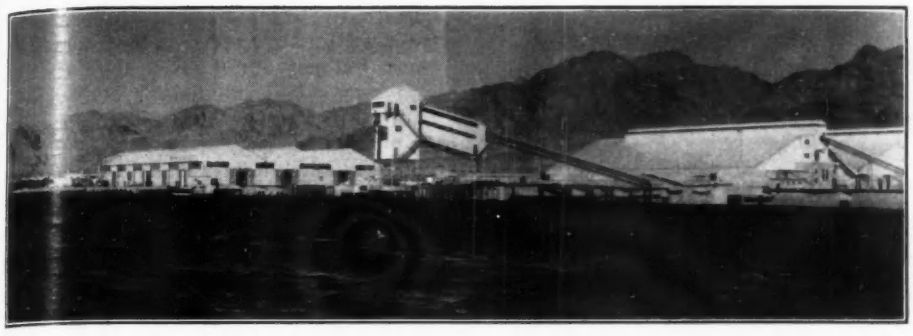


Fig. 6. View of General Cargo Berth and Transit Shed; Phosphate Berth (on right).

full cargo of 10,000 tons in 2 or 3 days, instead of 2 weeks as had hitherto been the case with lighters. Costs of complete loading operations, including storage, will drop from about 14 shillings to an average of 4 to 5 shillings per ton. Substantial savings will also be made on ocean freight rates and on demurrage. Also heavy losses through wind will be almost eliminated. The erection of the new plant was therefore an essential contribution to the success of future exports of Jordan's high quality phosphates. It is felt however that justice cannot be done in this article to the plant and our next issue will include a description of this in greater detail.

The present plant should be able to handle up to 750,000 tons of phosphates per year without undue congestion, the main limiting factor is the relatively low storage capacity of the two stores. As soon as a level of exports of about 600,000 tons per year is reached, it will be necessary to take steps for erection of a second phosphate berth, on the site foreseen for this purpose immediately south of the present berth. Experience gathered in running the present plant will be used for making improvements in the design of the second one and arrangements will be made to reach all holds of a vessel with help of a pivoting shipping conveyor or of another conveyor running parallel to the water face and provided with a travelling loading boom.

Such a costly refinement was not included in the present plant because, in 1953-54, when the basic design had been prepared, prospects for phosphate exports were less certain than today and the intention was to provide modern but relatively inexpensive loading facilities. However, numerous essential improvements have been introduced into the original plans, namely drag scrapers, exhausters and filters and dumping platforms.

Oil Terminal

In the summer of 1958, as already mentioned, imports of petroleum products from refineries in Syria and Lebanon were stopped. The Jordan Government had no alternative but to go ahead with the long postponed idea of building a small oil terminal in Aqaba. In a rush, a tank farm was erected in November 1958—April 1959, at the site foreseen for that purpose in the U.N. expert's basic plan of June 1952. Tanks have been connected by pipelines to the phosphate loading berth and a general view of the tank farm can be seen on Fig. 9.

The oil terminal is used for imports of refined petroleum products, petrol, kerosene and diesel fuel oil. The Tank Farm consists of 12 tanks, in three groups of 4 tanks each, of a total capacity of about 16,000 tons. Tanks are located at a distance of about 300 metres from the sea and at an elevation of 17 to 33 metres. They are connected by three steel pipes of 6 and 8 inches diameter, to one of the large central dolphins of the phosphate berth, where simple facilities have been provided for handling hoses. Tankers up to about 20,000 tons deadweight can be safely moored alongside the dolphins and petroleum products are pumped through the various pipelines to the tank farm.

In due time some of the tanks will probably be moved to the site of a new oil refinery north of Amman, the construction of which was started early in 1959. Crude oil for the refinery will be supplied, not via Aqaba, but direct from the major pipelines which cross Jordan on their way from the oil fields on the Persian Gulf to the Mediterranean coast in Lebanon. A certain number of tanks will be left in Aqaba for bunker oil and for emergency imports.

Auxiliary Works

Various auxiliary works have been provided for the new port area. As previously mentioned, an electric power station has been equipped by Brush Electric with three diesel electric generating sets of 360 KVA each and one unit of 225 KVA, giving an available capacity of 945 KVA with one set as standby. A part of the power will be made available to the village of Aqaba, to supplement several small municipal generators.

A supply of excellent drinking water has been arranged by the port department, not only for the port area and for vessels, but also for the entire village. Workshops for repair and maintenance of mechanical equipment have been built near the power station, in the rear of the general cargo berth. Shelters for mobile cranes, special stores for inflammable cargoes, weighbridges, fences and pleasant canteens for port workmen and port officials, with modern washing facilities, complete the list of auxiliary works in the new port area.

Flashing navigation lights have been provided near the Lighter Basin (two red lights) and near the lighter wharf (one green light) in order to assist vessels entering the anchorage area. A meteorological service has been established and radio station for communication with approaching vessels is being erected.

Future Developments

With the opening of the new port area, the immediate requirements of the traffic

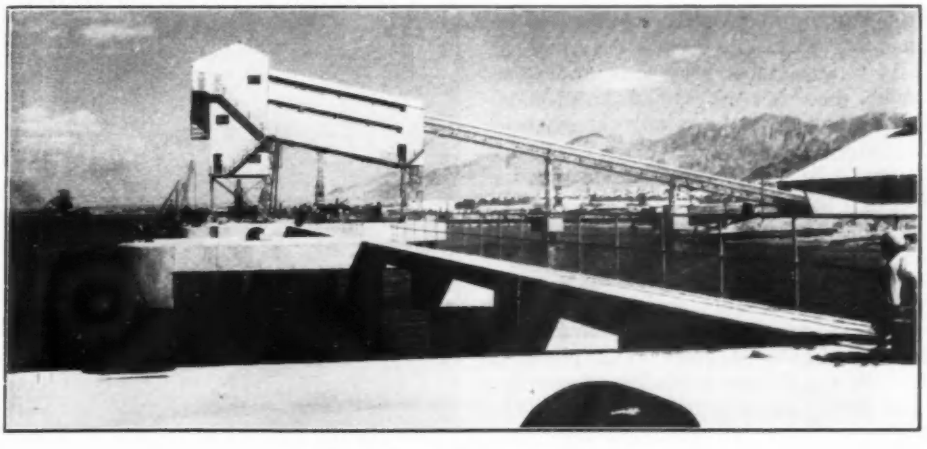


Fig. 7. The Phosphate Loading Berth.

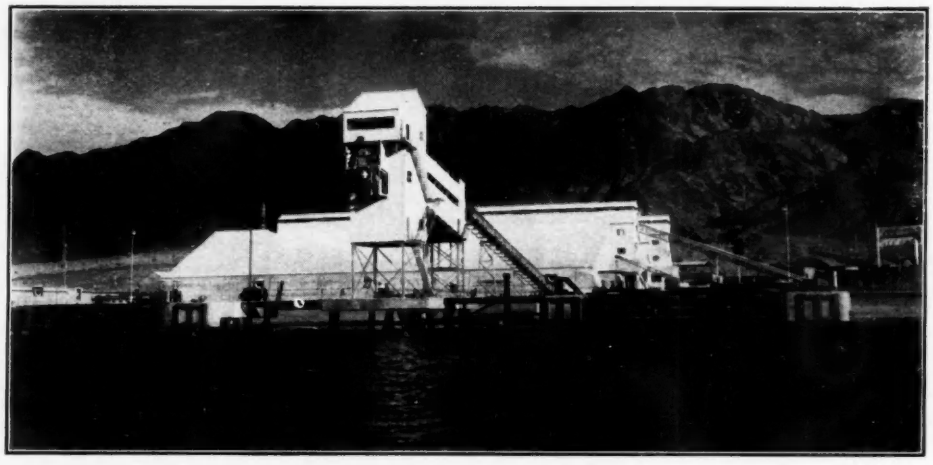


Fig. 8. View of Phosphate Loading Plant.

appear to have been met with respect both to imports of general cargo and to exports of phosphates. At present the most urgent task is to complete as soon as possible construction of the highway connecting Aqaba with Amman. No port can properly develop without good connections with its hinterland and Aqaba is no exception to this rule.

Once a proper road has been built, it is hoped that it will be possible to win for Aqaba the important transports of the UNRWA, the United Nations agency for the care of Palestinian refugees, half a million of whom are receiving UNRWA help in Jordan. There are also excellent economic prospects for attracting to Aqaba a part of transit of general cargo for Iraq, in order to avoid the time absorbing sea voyage around the Arabian Peninsular to Basra—a distance of more than 3,500 nautical miles. When normal relations between Jordan and Iraq are re-established and the highway is completed, this traffic could certainly be organised. An asphalted road connects northern Jordan direct with Baghdad through the eastern desert and the distance from Aqaba to Baghdad by road will be less than 800 miles.

In view of these prospects of increased traffic, there is a widespread desire in Jordan to proceed at once with the extension of the deep water general cargo wharf, in order to be able to accommodate two or even three vessels at one time and to reduce further the necessity of discharging ships on anchorage into lighters. A certain difficulty in connection with building a second general cargo berth consists in the high costs of construction of the wharf. The unusual length of steel sheet piling, 27 metres, and the great number of very long steel box piles supporting the 18 metres wide platform of the wharf, necessitate a heavy supply of costly imported steel and result in a high unit cost per metre run of the wharf. In case of an extension, it has been suggested that it would be advisable to examine carefully the possibility of adopting a less costly design, or perhaps using concrete piles instead of steel.

When assessing the total costs of the deep water berths in Aqaba, it should however be kept in mind that for an average port on an open coast considerable funds must be spent on building breakwaters and on dredging an approach channel to the port area. These expenses have been entirely avoided in Aqaba so that the overall cost of a deep water port has been very moderate. Moreover, there will be no necessity for periodical dredging for maintenance of the depth.

Another possibility of extension of the present works is the building of a second phosphate loading berth. Expansion of phosphate exports from Jordan seems to depend mainly on conditions on international markets. Strong competition of inexpensive Florida pebble phosphates has reduced Jordan's previous prospects of exports to Japan. In the East, India and Ceylon remain as potential buyers, while in Europe demand for Jordan's phosphates is increasing in Yugoslavia, Poland, Czechoslovakia and Italy. Should more than 750,000 tons of phosphate be shipped yearly via Aqaba, the present plant with its storage capacity of 40,000 tons will not be sufficient for a regular flow of exports; vessels might be obliged to wait with the resulting charges for demurrage. Plans for a new phosphate plant should therefore be prepared in advance so that construction can be started without delay in case of a favourable development of the sales.

Various improvements of a smaller scope will certainly be gradually made within the port, such as increased mechanisation of cargo handling through purchase of fork lift trucks and probably of additional electric gantry cranes. A sheltered area for lighters and other harbour craft should be arranged at the northern end of the extended general cargo wharf. Facilities on land for Moslem pilgrims proceeding to Mecca via Aqaba and Jeddah will be needed as soon as this very promising traffic is resumed. It had been increasing from year to year till 1956 but it stopped entirely in 1957 due to political unrest and to transit difficulties through neighbouring Arab States.

Experience of the last 8 years and favourable prospects for the near future, seem to have proved beyond any doubt that the development of a national port for Jordan at Aqaba was an absolute economic necessity. For a small country like Jordan, a yearly turnover in a newly created port of 600,000 tons of cargo, more than half of which consists of valuable imports, must be considered as a quite remarkable achievement.

(To be continued)

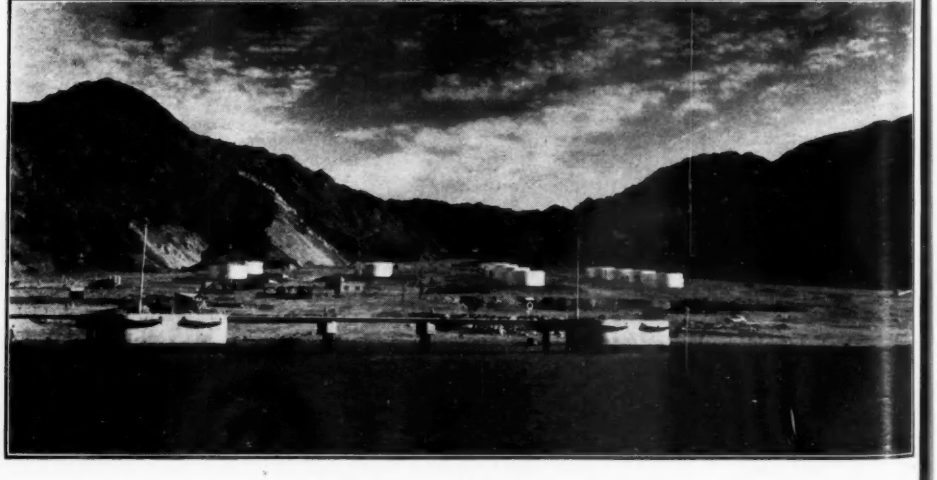


Fig. 9. View of the Tank Farm.

Mooring Dolphins for the Harbour of Kitimat

By A. BERNUPS, M.E.I.C.
(Senior Civil Engineer, General Engineering Department, Aluminum Company of Canada, Ltd.)

Application of large diameter high tensile, low alloy tubular steel piles made possible the design and construction of flexible type mooring dolphins for Kitimat Harbour. The flexibility of long artificial piles was utilized to absorb the berthing impact energy of large cargo vessels and also to resist the static mooring loads. Unconventional pile handling and driving methods facilitated the execution of work in the harbour with 20-ft. tidal variations. Simplicity of the design and a careful scheduling of all construction phases were two governing requirements.

GROWING aluminum smelter capacity necessitated in 1956 the planning of additional harbour facilities at Kitimat. The first harbour structure built at the early stage of the development was a temporary timber pile wharf which served mainly for plant construction purposes. Subsequently this wharf was used for handling coastal traffic for Kitimat Townsite. A reinforced concrete caisson type wharf was constructed in 1953, providing berthing space for ocean-going cargo vessels up to 30-ft. draft. This structure which is 760-ft. long is known as Terminal Wharf No. 1 and is equipped to handle all inbound shipments of raw material as well as outbound shipments of metal.

Fig. 1 shows the existing and planned possible future harbour development including the mooring dolphins, installed in 1958.

Requirements

At the end of 1956 the Terminal Wharf already had a berth occupancy figure of 40% and with additional new potlines under construction it was necessary to plan an extension for the berthing of cargo vessels.

Fig. 1 shows that the original wharf was designed and located so that a future extension southward was possible. However, an expensive wharf extension did not appear economically justified in 1957; therefore, to cope with the immediate future requirements, an installation of mooring dophins was decided upon. The dophins had to provide safe mooring for a vessel arriving in the harbour while the wharf was occupied. For any cargo handling operations the vessels had to be moved to the Terminal Wharf as soon as a berth became available.

From consultations with officials of Saguenay Shipping Ltd., who operate most of the ships using Kitimat Harbour facilities, the following requirements were established. Two main dolphins or "strength dolphins" were to be designed to resist impact forces resulting from the berthing of a ship. The same structures were to resist afterwards the pull of the ship's spring and breast lines. Apart from that it was found necessary to install two "end dolphins" to hold the bow and stern mooring lines after the berthing of the ship and to provide some additional resistance along the line of dolphins.

Parallel with the design of the mooring dolphins, the planning of the ultimate harbour development was advanced and the dolphins were located to allow for a future Terminal Wharf extension of 750-ft. As shown in Fig. 1., the dolphins are situated south of the wharf at the entrance to the dredged harbour basin and only some 500-ft. away from the deep water of Kitimat Arm.

The prevailing winds are nearly due north or due south, following the direction of the valley. This factor had already been considered in the original harbour design. The mountain ranges offer some wind protection, particularly from the West; however, wind velocities up to 60 m.p.h. have been recorded and during several storms velocities up to 80 m.p.h. have been estimated. The effect of such winds had to be considered.

The axis of the installation was selected so that the fendering of the dolphins lines up with the fendering of the wharf. The centre-to-centre distances of the dolphins were chosen to allow for mooring of vessels from 10,000 to 16,000 T.D.Wt.

As the basis for the design the following data were to be used:

Load displacement of ship, representing the moving mass of a 16,000 T.D.Wt. cargo vessel:	24,000 sh.t.
Maximum angle between ships approach line and line of dolphins	15°
Maximum approach speed of a vessel normal to the dolphins	0.5-ft./sec.
Wind pressure	20 lb/sq.ft.

Selection of Dolphin Type

Prior to the selection of mooring dolphins a mooring buoy alternative was investigated. The depth of water at the possible location of a mooring buoy in Kitimat Arm is about 60 fathoms and the bottom consists of silt. Detailed studies showed that the ground anchorage and the methods for laying the ground tackle would be complicated. This alternative also had the disadvantage that extended pilot service would be required while the ships were at the anchorage, some 5,000-ft. away from the wharf. The scheme was abandoned finally.

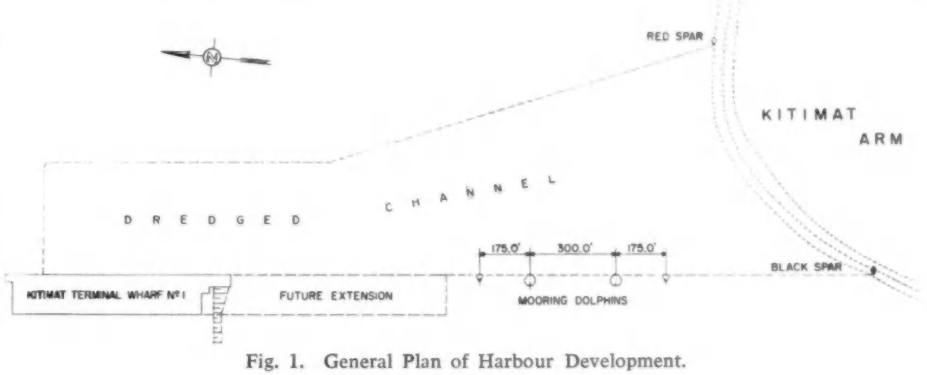


Fig. 1. General Plan of Harbour Development.

Several dolphin arrangements and types of pile construction were studied before the final design was adopted.

The construction methods had to be as simple as possible to cope with the extreme tide conditions varying between elevations of +0.58-ft. and +23.08-ft.

Pressure creosoted timber piles were considered first but it was soon realized that the scheme was not very feasible because of the great number of batter piles required to resist the impact and wind loads. Also a concrete capping would be required to engage the resistance of all dolphin piles. Such concrete work would be very difficult because of the tide conditions.

Steel sheet pile cells 27-ft. in diameter penetrating the soil for some 40-ft. and gravel filled above the bed elevation, offered reasonable factors of safety but the costs involved were found to be high compared

to other choices.

Further studies revealed that flexible vertical steel piles could be used with advantage to absorb impact energy of a vessel, although this flexibility has some disadvantage for resistance to static mooring loads.

The selection of this dolphin type was influenced also by technical articles, describing successful flexible dolphin installations of similar type at the Port of Amsterdam.

As shown in Fig. 2., the final design used long, vertical, tubular steel piles as flexible members to absorb the ships' kinetic energy. Seven piles were used for each main dolphin and three piles of the same type were used for each of the end dolphins. Two horizontal steel platforms for each dolphin were introduced to provide the tie between the piles. As the platforms are supported loosely on the brackets at the piles, the lateral loads do not cause any appreciable axial pile loads. The tubular piles offer equal resistance to lateral forces from any direction and each pile is acting essentially as a long cantilever. It was proved later that the fabrication and erection of steel platforms was a comparatively easy job, considering the tidal conditions, while the handling and particularly the driving of tubular piles involved some problems.

Soil conditions

The topography of the Kitimat area is characterised by high peaks and low valleys. A large delta area with tidal flats has been formed by the Kitimat River which empties into a fjord known as Kitimat Arm. The floor of this valley is at great depth and bedrock beneath the tidal flats is covered by post-glacial sediments, varying in thickness up to a maximum of 450-ft. The deposition of these sediments has been affected by fluctuating coastline and ocean levels.

Extensive soil investigation was carried out in the harbour area in 1952 before the construction of the Terminal Wharf. Altogether twelve borings were made at that time to determine the soil profile, the penetration resistance, and to obtain the necessary soil samples for laboratory testing. The borings covered the area of the initial wharf site as well as the future wharf extension area and the site of the present mooring dolphins. Fig. 3 shows stratigraphy and penetration resistance of soil from the two borings nearest to the site of the dolphins.

The soil below the dredged bottom elevation—31.0-ft. can be classified as complex granular non-cohesive material, consisting mainly of fine silty sand of medium density. Consolidated undrained tests indicated an angle of internal friction varying from 20° to 43°, with an average of 30°. Most of the soil samples had little or no cohesion with a maximum value of 1,000 lbs. per sq. ft. The in-situ dry density of the soils varied between 80 and 95 lbs. per cu. ft., while the water content varied between 30% and 43%.

Pile loading tests were carried out in the harbour area in 1957, with the main purpose of determining the permissible pile

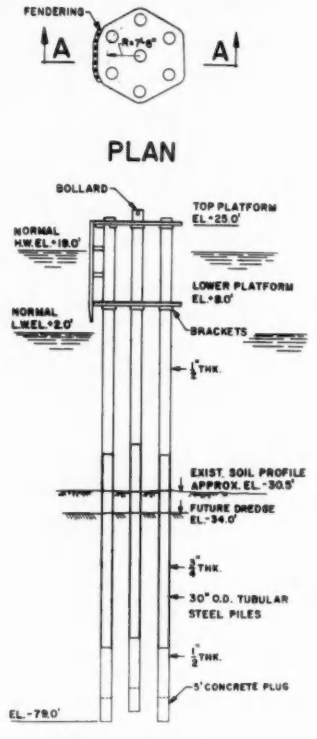


Fig. 2. Main Dolphin.

loads for a possible future wharf extension on piles. The tests supplied also some information for the dolphin pile design.

A characteristic time-load-settlement graph for one of the test piles is shown in Fig 4. Altogether six loading tests were carried out with four piles.

Ultimate loads yielded average skin friction resistances of 750 lb. per sq. ft. for 14-in. H piles and 1,000 lb. per sq. ft. for a 12-in. diameter tubular steel pile with a conical tip, assuming that in both cases the loads were transmitted to the soil entirely by skin friction.

It was apparent that the shape of the pile had some effect on the pile resistance. While the H pile was merely cutting the soil, the cylindrical pile acted as a soil displacing pile. It was further observed that an increase in penetration depth of the piles within the same soil layer did not produce a proportional increase in driving resistance. This leads to the conclusion that the prolonged driving affected the pore pressure of the surrounding soil and reduced the shear resistance of it. On the other hand, piles regained driving resistance after some period of rest and nearly became "frozen". This was evidenced during the redriving of piles and after field splicing of piles.

Apart from supplying information on possible frictional values, the tests gave an indication of the difficulties which could be expected when driving large diameter piles. Suitable equipment had to be chosen to overcome the frictional and end resistances of the piles and the driving methods had to be planned to ensure continuous driving for each pile. Splicing of piles during the driving was ruled out completely because of the danger that they might become "frozen".

Design of Dolphins

The design took into account the future planned dredging of the harbour basin down to El.-34.0-ft. Loaded and unloaded vessels were considered in determination of the wind force on the ship. Further, it was assumed that from the total kinetic energy of the berthing ship only 50% will be absorbed by the two main dolphins, while the rest of the energy will be lost due to the water displacement in a broadside movement towards the dolphins, and due to the loss of energy on first impact.

Two cases of berthing were considered:

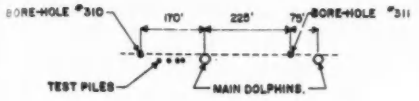
(a) Broadside collision of the vessel with the main dolphins, engaging both structures simultaneously. In this case the energy to be absorbed was considered equally distributed to both structures;

(b) Collision with only one of the main dolphins. Because this type of impact is unlikely to occur amidships, a reduction coefficent of 0.5 was used for the moving mass.

Hence, in either case, the energy to be absorbed by one main dolphin was the same. It follows that in case (a) the dolphin absorbs the energy in pure bending, while in case (b) the structure may be also subjected to torsion, caused by a glancing blow.

Comparative design studies revealed that high tensile, low alloy steel piles can be utilised better than medium structural grade steel pipes to resist the cantilever moments for this particular structure. Welded steel pipes of 30-in. diameter, complying with ASTM Specification A-252, Grade 3, were selected, having an ultimate tensile strength of 75,000 psi. and an ultimate yield stress of 45,000 psi. The use of this steel offered considerable saving in pile transport, handling, field welding and driving costs as compared with medium structural grade steel piles.

Considering the nature of the design loads it was decided to use a maximum working stress of 37,500 psi. for cases of



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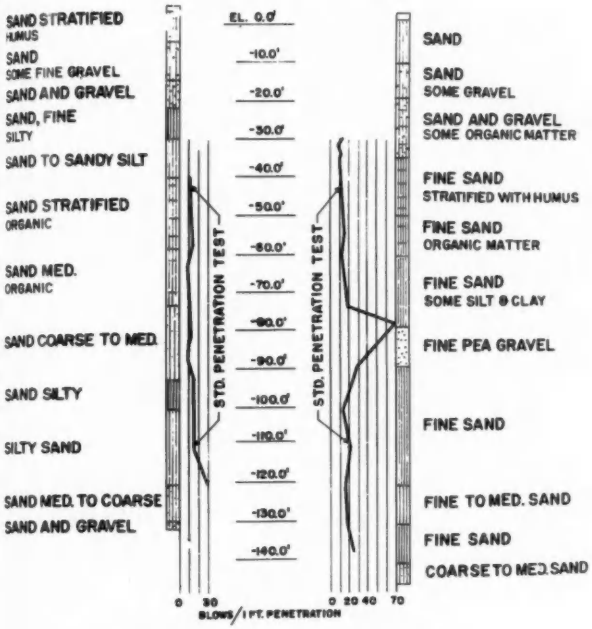

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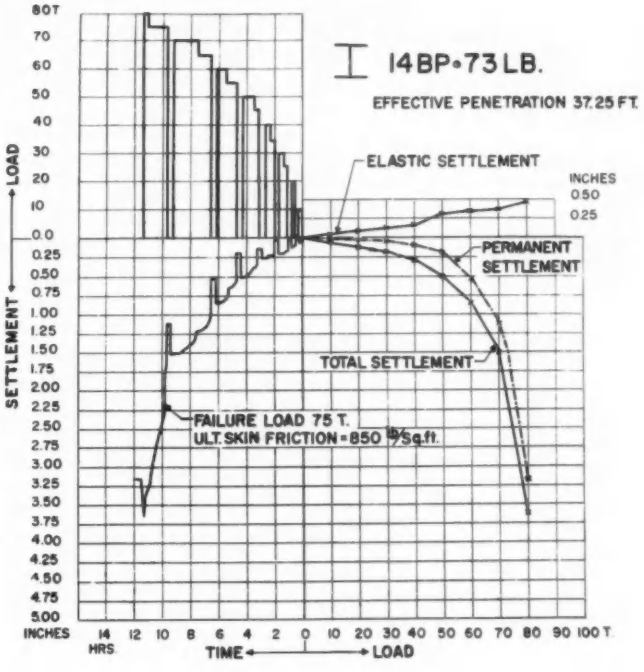

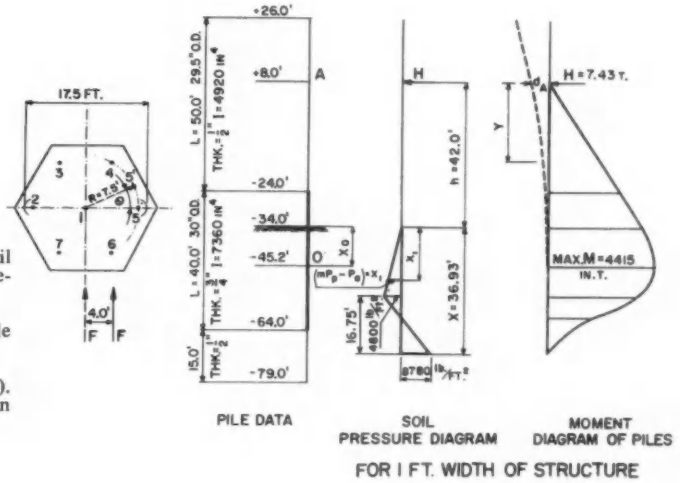

FOR 1 FT. WIDTH OF STRUCTURE

Fig. 3. (above). Soil Stratigraphy and penetration resistance.

Fig. 4 (top right). Pile loading test data.

Fig. 5 (bottom right). Main Dolphin design data.

pile bending. This means a theoretical factor of safety of 1.2 against yield failure and a factor of safety of 2.0 considering the ultimate strength. Actually the inspection tests during the fabrication of the piles showed that the ultimate stress of the material varied between 78,000 and 89,000 psi. and the yield stress was between 52,000 and 59,000 psi. Test specimens from welded joints had an ultimate strength of 81,000 to 84,000 psi. and a yields tress of 53,000 to 55,000 psi.

As the platforms are resting loosely on brackets welded onto the piles, all connections can be considered as hinges. The structure is so flexible, that under the maximum forces the slope of the timber fendering exceeds the probable tilt of the ship. For this reason it was assumed that the point of load application for wind thrust and impact forces will shift to the elevation of the lower platform.

Except for loading Case (b), the loads have been assumed uniformly distributed to all dolphin piles.

The penetration depth of the piles was determined following the methods used for cantilevered steel sheet piling. The soil between the piles was included in the effective width which appeared to be a justified assumption considering the 7-ft. 6-in. centre-to-centre spacing of the piles.

For calculations of the soil resistance the following soil properties were used: (*see equation I*)

In order to have a consistent overall factor of safety, the penetration depth was designed for a theoretical lateral force on structure, required to produce simultaneous yield of steel and ultimate soil resistance.

A summary of calculations for the main dolphins is shown in equation II as well as in Fig. 5.

Actually the specified penetration depth was made 8-ft. greater than the theoretically calculated 37-ft., to provide some allowance for the uncertainties in soil conditions.

The bending moment diagram, shown for 1-ft. width of structure, allows to compute moments and corresponding deflections and stresses for various design loads by use of co-efficients.

The greatest lateral force was found to be a wind thrust of 90 T. per dolphin. Corresponding maximum bending moment per pile:

Equation III

$$M = 4415\frac{17.5\times 90}{7\times 130} = 7640 \text{ in t.}$$

Stress

$$f = 31200 \text{ psi.}$$

Deflection $d_A = \int_0^A \frac{M_y Y dy}{EI_y} = 11.3$

Kitimat Mooring Dolphins—continued

It was found convenient to determine first the deflection for a load of 1T per pile $d_{A1}=0.88$ in. and use it as a basis for further calculations.

The highest stresses in piles were found to be due to eccentric impact forces. (*see equation IV*).

The twist of the structure is represented by an angle θ. Except for the centre pile, all other piles undergo a displacement of $R \times \theta = 90\theta$ in. Total torsional moment on six piles. (*see equation V*).

Since the structure undergoes torsion and bending at the same time, the sum of both energy quantities represents the total energy absorbed by the structure. (*see equation VI*).

It should be noted that the deflections were defined assuming that the effective point of fixation coincides with the point of maximum moment. It could be expected that the effective resistance of the soil changes as the lateral load is increased. Although the point of maximum moment remains at essentially a fixed elevation, the effective point of fixation moves downward as larger loads are applied. Consequently the extreme calculations could be expected larger than calculated.

For the design of end dolphins a static pull, governed by the breaking strength of 8-in. ropes was considered. According to the marine experts a vessel may have up to three 8-in. manilla ropes tied on a bollard of the dolphin. The breaking strength of one rope is 21 tons. Since it is unlikely that all ropes will be stressed to the same extent and near their breaking strength, it appeared to be justified to use a design load of 30 tons. The calculated maximum bending stress from this load was 36,000 psi. and the maximum deflection for the structure at El.+26.0-ft. was 20-in. Comparative calculations were made combining the effect of a wind force on ship and the drag from a current of 3.5 knots. Assuming this force equally distributed to one main dolphin, and one end dolphin, the resulting force on an end dolphin was 28 tons.

The platforms were designed as diaphragms, each made up of a single ⅜-in. thick checkered steel plate with stiffeners. A tolerance of ±6-in. was allowed for locating each individual pile in plan, which later proved to be adequate. Creosoted B.C. fir timber fendering was used in front of the dolphins as shown in Fig. 2. To lessen the effect of glancing blows on the structure, the fendering was curved towards the sides of the dolphins. Each dolphin was also equipped with steel ladders and handrailing.

Construction of Dolphins

The main construction problem was the driving of the large diameter piles. Ultimate pile resistance was expected in the

Equation I

Submerged weight of soil ..... $w=65$ lbs. per cu. ft.
Angle of internal friction ..... $\phi=30$ degrees
Cohesion ..... $c=0$
Factor to allow for wall friction in Rankine's value of coefficient of passive earth resistance ..... $m=1.33$

Equation II

Soil pressure increment per 1-ft. of depth ..... $mp_p-p_a=238$ lb./ft.^{2}
Effective width ..... $B=17.5$ ft.
Required M.R. of soil for 1-ft. width, based on yield strength of piles ..... $M_r=736{,}000$ ft. lb.
Maximum bending moment for piles is at depth .....

$$X_o=\sqrt{\frac{2H}{mp_p-p_a}}$$

$$\max M=M_r=H\left(42+\sqrt{\frac{H}{119}}\right)-\frac{238}{6}\left(\sqrt{\frac{H}{119}}\right)^3=736{,}000 \text{ ft. lb.}$$

$H=14860$ lb.$=7.43$ T. $\qquad X_0=11.2$ ft.

Corresponding force on structure ..... $F=7.43\times17.5=130$ T.
From equation

$$X^4-\frac{8H}{mp_p-p_a}X^2-\frac{12Hh}{mp_p-p_a}X-\left(\frac{2H}{mp_p-p_a}\right)^2=0$$

necessary penetration $\qquad X=36.93$-ft.

Equation IV

Energy absorbed by structure in bending only $\qquad E_B=0.5\frac{0.88}{7}F^2=0.0629F^2$ in. t.

Energy absorbed by six piles in torsion
Assuming force F acting on structure with 4-ft. eccentricity $\qquad E_T=0.5M_T\theta$

$M_T=48F$ in. t.

Equation V

$$M_T=6\frac{90\theta}{0.88}\times 90=55300\theta \text{ in. t.}=48F \qquad \theta=0.00087F \text{ (Radians)}$$

$$E_T=0.5\times 48F\times 0.00087F=0.0209F^2 \text{ in. t.}$$

Equation VI

$$E=E_B+E_T=(0.0629+0.0209)F^2=0.0838F^2 \text{ in. t.}$$

Energy from ships impact

$$E=0.5\times0.5\times\frac{mv^2}{2g}=23.4 \text{ ft. t.}=282 \text{ in. t.}$$

say 300-in. t.

Force on structure $\qquad F=\sqrt{\frac{300}{0.0838}}=59.9T$

Maximum displacement of a pile at EL.+8.0-ft.

$$d=\frac{0.88}{7}59.9+0.00087\times59.9\times90=12.22 \text{ in.}$$

Maximum force on a pile $\qquad F=\frac{12.22}{0.88}=13.9T$

Maximum stress $\qquad =36200$ psi.

range of 200 to 300 tons, therefore, driving equipment had to be of the heaviest type.

An open end tubular pile may act during driving like a closed one, because of the clogging of soil inside the cylinder. The jetting of piles was not desirable because of possible soil disturbance. The heaviest expected heavy driving the pile was constructed for simplicity and economy with a flat end.

The 105-ft. long piles were fabricated and shipped to the site in units of 50-ft. and 55-ft. lengths. Concrete of 3,000 lb. strength with 15% additive by weight of cement was used for the plugging of the 55-ft. long bottom units. After a hardening period of 3 days the pile units were moved to the welding bed for splicing. Prior to welding, the material was preheated to 450°F. by means of a burner coil. The preheating temperature was controlled by use of heat sensitive crayons. To slow down the cooling of the material, the joint was kept covered with asbestos blankets for 2 hrs. after welding. All field welding was carefully inspected and a number of radiograph films were made to check the quality of the welding.

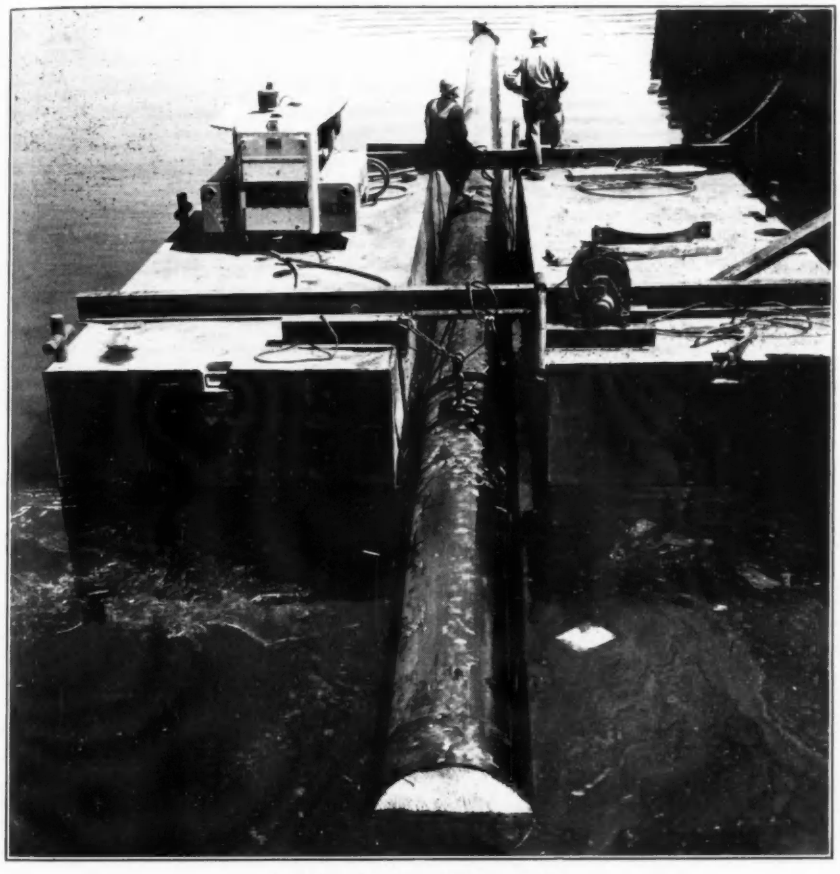

Fig. 6. Floating of Piles to Site.

The upper end of the pile was temporarily sealed off and the whole pile assembly weighing 12 tons was floated to the site at high tide by use of two pontoons equipped with air winches as illustrated in Fig. 6.

Fairly accurate location of the piles was obtained by means of markers on the shore and markers and templates fixed on the barge. The barge, carrying the driving rig, was moved into the final accurate location by use of four air winches, adjusting the length of four anchor cables from the barge. Prior to the pile driving, a packing of sand and crushed stone was placed on top of the concrete plug to cushion the hammer blows. More packing was added from time to time during the driving as soon as it was noticed by sound that the packing had been pulverized and compacted to the point where it no longer acted as a cushion. Up to 16-ft. of packing was used for some of the piles.

In general, the hardest driving was experienced for the last 20-ft. of the total penetration of approximately 50-ft. Fig. 7 shows the driving energy used for penetration of one of the main dolphin piles, which may be considered as typical for the majority of the piles. It is questionable whether any of the known dynamic pile driving formulae is applicable in this particular case. It could be expected that a great deal of energy was absorbed by compaction of the packing and elastic deformations of the pile. It was estimated that the ultimate resistance of a pile is in the neighbourhood of 300 tons. Several piles were inspected visually from the inside after completion of the driving. Inspection did not reveal any sign of damage to the pile, nor any noticeable deformations. The average time for locating and driving of a pile was one day. Most of the driving was accomplished in 4 hours per pile. Templates were made to fit the as-driven pile locations. The platforms were then assembled on the shore from prefabricated elements using these templates.

The platforms and all external surfaces of the piles were painted with a coal tar paint applied in two coats. In addition to that, a sacrificial magnesium anode system was installed. It is expected that this system

locally available double acting steam hammer with 20,000-ft. lb. energy per blow was considered to be inadequate for this job. For all practical purposes, driving with a heavy drop hammer appeared to be the best solution. In order to avoid reinforcing the pile head, the driving was carried out with a hammer, dropping inside the pile cylinder and delivering the blows to a 5-ft. long concrete plug, poured at the bottom of the pile.

This method offered good control over the plumbness of the pile during driving. Also, the energy of the hammer was used more efficiently when applied at the pile tip. In some respects this unconventional driving method is associated with the principles used for caisson-pile driving. In fact, the largest type pile driving rig, equipped with a hammer of 8,000 lbs. weight, was used for the job. The method chosen simplified the pile preparation and generally proved to be successful. As it was not certain that a conical pile tip would ease the

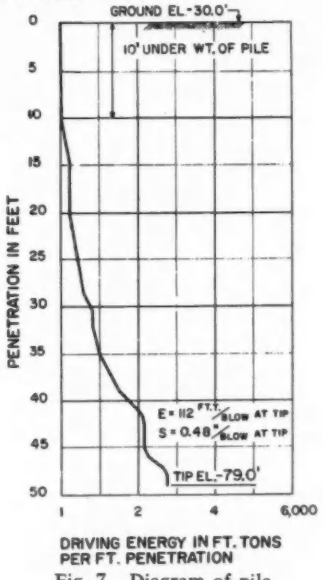

Fig. 7. Diagram of pile driving energy used.

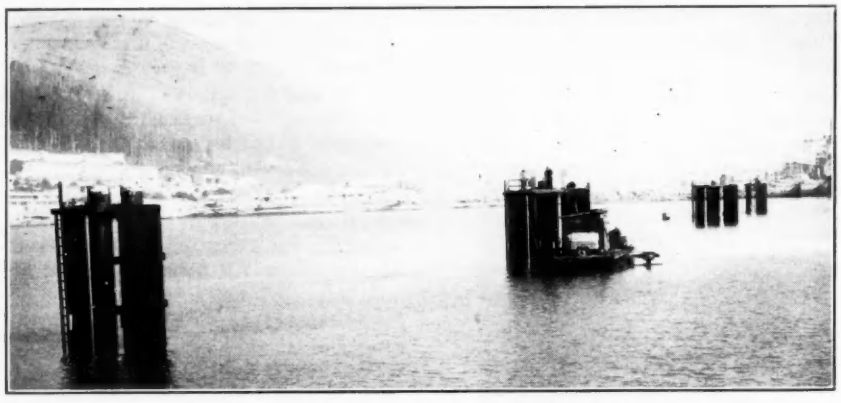

Fig. 8. Complete installation of Mooring Dolphins.

will be replaced by an impressed current cathodic protection installation, following the construction of any future wharf extension.

The B.C. Fir pressure creosoted timber fendering units were prefabricated on the shore and later fastened on brackets of the dolphin steelwork.

The field work for all four dolphins, including the pile preparation, required three months' time. The work on water was very much affected by the tide conditions.

The installation was completed on 25th July 1958. Fig. 8 shows a general view of the completed mooring installation.

Since the completion of installation several ships have used the new mooring facilities. None of the ships has been moored during extremely rough weather, but moderate winds have been experienced. During one of the mooring operations, repetitive pulling forces due to the tightening and slackening of lines produced 18-in. deflection of the northern end dolphin. However, no permanent deflections have been observed. It could be expected that the 300-ft. distance between the main dolphins will be to greater advantage for the future large cargo vessels than for the present ships of medium size. The present general experience indicates that the installation provides a satisfactory service.

Acknowledgments

The design and detail construction drawings were prepared by the General Engineering Department staff of the Aluminium Company of Canada, Limited, under general direction of J. F. Braun, M.E.I.C., Chief Civil Engineer. The General Contractor for this work was Saguenay-Kitimat Company. Mr. H. C. Jenkinson, Vice President of the company, directed the work in field. Franki of Canada Limited was engaged as subcontractor for the pile driving work and Mr. L. A. Fraikin, Managing Director of Franki, contributed useful ideas for the execution of the work. Mr. H. Jomini was Alcan's resident engineer in Kitimat.

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Wave Dissipation by Compressed Air (Pneumatic Breakwater)

By S. I. Radionov
(Translated by Hildegard Arnesen)

The Wave Research Laboratory of the University of California has done a useful service in publishing this translation of a Russian article on the Pneumatic Breakwater from "Ocean Transport", Moscow 1958. It has 41 pages including bibliography and 6 pages of drawings and diagrams.

In the article the author reviews the work done on the Pneumatic Breakwater in Russia including the experiments carried out in the middle 1930's by I. A. Bogolepov both in the laboratory and in the Black Sea; the laboratory work done by Professor P. K. Bozhich in Moscow; by Mr. V. V. Kuybyshev also in the laboratory and the more recent mathematical studies of Mr. Teplov. He comes to the general conclusion that this method of calming waves has a good prospect of being useful in practice.

In connection with another prototype test carried out in the Black Sea he records that waves 12 m. long x 1.5 m. high and wave period 3-4 seconds in water 10 m. deep were reduced to 0.2 m. high with an expenditure of 1.5 cu.m. per minute per metre (25 litres per second per metre) of air at 7.5 atmospheres. The horizontal surface currents were measured but no figures are given.

The article includes a detailed mathematical analysis of the physics of a curtain of bubbles rising through the water with its effect on waves and the effect of waves on it. The contribution that the horizontal surface current may make to the problem is not taken into account in this part of the paper while the existence of reflection of waves at the bubble curtain is deduced from theoretical considerations.

The author considers that wave reduction by pneumatic breakwater is due to:— "Wave reflection from the wave curtain; dissipation of the energy of the particles of the liquid in a strongly turbulent zone above the perforated pipe-duct; expenditure of wave energy on the communications of the accelerated horizontal motion of air bubbles together with the added mass of water, and the expenditure of wave energy on the compression of the air bubbles."

In summing up the practical value of the pneumatic breakwater the author stresses the difficulty of assessing from model experiments the amount of air required full scale, but he suggests that the consumption would be heavy. Nevertheless he considers that the method should find wide application in practical work such as a temporary device for protection against waves in constructing marine works or in protecting some of the structures of the oil industry or for preventing the entry of waves through harbour mouths.

Most of the work described in the article was done in Russia and the accounts of experiments are carried up to 1955.

New Hydrographic Survey Launch for British Guiana

In June this year a grant of £330,000 was made under the Colonial Development and Welfare Acts towards the cost of sea defence works in British Guiana, of which more than £30,000 will be spent on a new hydrographic survey launch to be used for investigations into Georgetown Harbour Bar siltation and into erosion and accretion to the east and west of the Demerara River estuary. This work will be carried out by oversea staff financed with assistance from the U.N. Special Fund.

The Hamburg Port Health Authority

A Review of its Organization and Working Practice*

By Dr. med. WALTER KOCH
(Director of the Port Health Authority, Hamburg)

WHEN I was awarded a Fellowship of the World Health Organization in 1956 it was the first time that opportunity presented itself to study the organization and achievements of the Port Health Service in the international ports of London and Liverpool. May I, on this occasion, express once again my special thanks to Dr. Greenwood Wilson and Dr. Pierce who helped me to acquaint myself with all branches of their activities. My first visit to their departments was the commencement of a splendid and useful collaboration.

Doubtless the basic principle of our duties is similar in all ports of the world. The essential factor consists in preventing the importation of infectious diseases. However, some methods which we in Hamburg are adopting in order to achieve the best results, may be worth mentioning.

The war caused almost complete cessation of shipping traffic in the Port of Hamburg which resulted in a severe reduction of the staff belonging to the Port Health Service. Even during the first post-war years the situation appeared to be past all hope and nobody ever dared to presume that shipping traffic could recover to a noteworthy extent. The reconstruction of my office was at first neglected and little was done to meet the demand of the growing activity in the port.

Another difficulty arose from the fact that those who provided the funds for the reconstruction and improvement of my department based their allotments upon the transfer of goods—the amount of cargo being discharged. Unfortunately Hamburg is the terminus in the series of Northern Range Ports. Not more than a few kilometres east of our city runs a border cutting off the traffic to our former hinterland which, for the transfer of goods, had always been of the utmost importance to our port. On arrival in Hamburg a considerable number of ships carry no more than a small remainder of their cargo and, on departure, they are frequently found to be loaded as poorly as when they arrived. On account of the geographical location of our city the transfer of goods during the past years by no means increased to the same extent compared with the growing number of ships bound for Hamburg, and yet the number of incoming ships is the determining factor which accounts for the increasing amount of our work.

When, in 1955, I took over as Director of the Port Health Service in Hamburg, I had to face the task of keeping in step with the continuously growing duties which became even more pressing on account of the severe cut in office personnel. This situation called for a rationing policy in the performance of our daily tasks especially those concerned with inspection duties on arriving ships.

According to general practice there was a tendency up to 1958 to have an immediate check on all ships arriving at Hamburg. The relatively narrow navigable waters in the port, however, do not permit a hindrance of shipping traffic, as for instance anchoring or stopping a ship, etc. Thus the performance of Port Health duties by means of stopping and boarding a ship on the river before its arrival — often under pressure of time — frequently showed unsatisfactory results. For instance, when several ships arrived together a number would pass uninspected and could not be included in the Port Health Inspection Scheme. This made it necessary for them to be inspected immediately after being towed to their berth, thus causing our medical inspectors to be constantly on the alert for incoming ships. Considering the widespread area of the port the loss of time and working capacity can be appreciated. In addition, all the initiative of the outside squad, comprising 3 medical officers, 6 health inspectors and 2 officials employed on rat searching, could not possibly manage to inspect the average of 40 to 60 ships arriving daily at the port. Apart from ships restricted to quarantine regulations which, without exception were, and still are, visited by an official, many ships had to remain uninspected and who could tell for certain that one of these vessels would not prove to be of importance to the Port Health Service ?

I therefore decided to develop a method of allowing not only a check on all incoming ships, but also to group them in such a manner that:

1. According to an early receipt of information with regard to the state of health on board a ship the most important ones of the large number of arrivals could be picked out in time to ensure an immediate investigation and inspection, since it is known by experience that a relatively small number of ships have to be classified as being doubtful and unsatisfactory.
2. Arrangements for checks at random could be made for those ships of which we were not suspicious, which meant that supervision could work to a scheme enabling my relatively small staff to carry out their tasks with as little loss of time as possible.

When searching for this method I remembered an occurrence in Liverpool when a ship arriving at night obtained free pratique by a custom's officer after he had examined the Declaration of Health. The following day this ship was scrutinised by a Health Inspector with a view to checking the general state of health and sanitary conditions. A thorough check was carried out in the galley, the provision store rooms, the crew's quarters and lavatories.

I do not know whether this proceeding is generally adopted in your country or only in Liverpool, but it appeared to me very significant and would achieve more satisfactory results than a short questioning of a ship's master or his representative, a proceeding usually employed while a ship is being towed on the way to its berth, even though in cases of doubt many ports make it a habit to carry out medical mustering of the crew. However, I do not believe that it will ever be possible to see each individual member of the crew unless arrangements are made for all ships demanding inspection to ride at anchor in the roads which for us in Hamburg would be the Port of Cuxhaven. In the narrow waters of Hamburg this procedure would be impossible.

On the other hand a ship having obtained preliminary free pratique on account of a declaration of health would be in contact with the shore prior to a check by an official of the Port Health Service.

At all events, even a preliminary free pratique necessitates authorization by the Port Health Service in Germany. By our

*Abstracts of a Paper read at the Annual Meeting of the Association of Sea and Air Port Health Authority, Southampton, June 1960.

making use of a teleprinter of the ships' registration office all port authorities, i.e. harbour police, harbour pilots, and harbour master, as well as appropriate ship brokers are informed of a preliminary free pratique which we may use to issue immediately on receipt of a ship's declaration of health. In addition, the harbour police station of the pier concerned is notified of the medical clearance with our request to inform the master accordingly immediately on arrival of the ship. This procedure is of importance on account of the harbour police prohibiting public communication between Q-ship and shore until free pratique has been granted by the Port Health Authority. It is a general practice that an officer of the water police is present on arrival of a ship. Until all ships are equipped with radio telephone it will not be possible to contact masters of ships direct, in order to inform them about the clearance prior to their arrival. This, in my opinion, is not of importance, as everybody concerned ashore is informed about Port Health measures. A final free pratique will be given by an official of the Port Health Authority who will visit the ship and issue a certificate with regard to the medical clearance.

I therefore had to decide whether or not a free pratique is justified merely on account of a health report submitted in advance. This procedure is in compliance with regulations laid down by the World Health Organization and I am of the opinion that it is very unlikely for a ship's master to render a declaration of health which has not been completed with the utmost care, since he must always be prepared for a thorough check by the Port Health Service.

Further it must be regarded as an advantage that the issue of a preliminary free pratique—either on account of information received by radio or by any other kind of transmission, will cause no hindrance to a ship. The inspection to follow, which quite often will merely consist of spot checking will be carried out at a time when ship and health inspector may set to work quietly.

I will summarise the result of my reflections as follows:

1. A preliminary free pratique is justified on account of a declaration of health, provided thorough checks in sufficient numbers and extent are to follow, thus leaving open no possibility for a ship's master to risk rendering an incorrect report.
2. Where narrow and difficult waters prevail, as in the Port of Hamburg, a supervision of this kind will show more efficient results than could be obtained from a speedy questioning of ships' masters by health inspectors who are boarding a ship prior to its arrival in the port.
3. Better mobilisation of labour could be achieved by accepting health declarations rendered in advance, thus enabling my staff to work to a scheme when visiting and checking ships in the wide-spread area of the Port of Hamburg.
4. The receipt of a health report from all ships submitted to the Port Health Service, either by telegraphy or any other kind of transmission, could be organised in Hamburg without difficulty. An immediate inspection of every ship bound for Hamburg, however, represents a problem which cannot be solved with the small number of personnel at my disposal.
5. There is hardly any hindrance to a ship by Port Health measures if it is allowed to enter the port and set to work immediately without having to undergo extensive Port Health formalities. An inspection of the vessel and a check on the accuracy of the information received in advance could be carried out at a later and more convenient date.

The problem to be solved consisted in developing a system to ensure an early receipt of a health declaration of all ships submitted to the Port Health Authority prior to their arrival. For reasons which cannot be explained here it is not possible in Germany to engage another authority such as, in your country, the Customs Officers. Checking and controlling of ships has to be done solely by the Port Health Authority staff. The method advised by the World Health Organization to make use of radio with reference to a troublesome code of the International Signal Book, appears to me rather cumbersome. Besides, a system of that kind might prove to be too expensive, so that only a few ships would render a report. But it is important to obtain a declaration of health from as many ships as possible prior to their arrival and this could be done by making use of two possibilities:

1. The Maritime Declaration of Health which was developed in your country and taken over by the World Health Organization. This form has stood the test the world over and is now known to all navigators of ships.
2. The other possibility presented itself by a scheme specially adapted for Hamburg. It is an excellent registration system which, starting at lightship ELBE I, reports all ships until their arrival at the port.

Every ship bound for Hamburg is reported by teleprinters immediately after passing the following signal stations:

The first announcement after passing ELBE I; the second while passing Cuxhaven, a distance of 21 sea miles; the third while passing Brunsbüttel, a further 22 sea miles; the fourth while passing Stade, after having covered a further 23 sea miles; the fifth and last while passing the pilot station at the harbour mouth of the Port of Hamburg, after having covered a further 10 sea miles.

From the signal station at Cuxhaven to the Port of Hamburg all ships have to cover 55 sea miles, a distance requiring at least 5, and sometimes 8, or even more hours depending on the type of ship and current conditions of the river. By reading the teleprinter in my office we are in a position to supervise all traffic by means of signalling communications from a ship to a station on shore. It is also probable that in the near future all arriving ships will be contacted by radio telephone connection. This would facilitate matters in various ways, but as far as my office is concerned I am of the opinion that this never will replace signalling communications. A long distance call always permits the excuse of a misunderstanding if, later, information received previously turns out to be incorrect, especially in cases where difficulties in language exist. A concerted signal, however, is as plain as a written word.

It was of great importance to find a simple, but fool-proof code system for a signalling communication with regard to state of health. This presented itself with the Maritime Declaration of Health as a plain and negative answer to all of the 6 questions of this declaration form would suffice to form a correct opinion regarding health conditions on board a ship. We suggested therefore that, while passing the signal station at Cuxhaven, all ships being in a position to answer these six questions negatively, should hoist flag signal " 6," standing for the six questions on the form, and " N " standing for " No "—that is " 6 N " (see Fig. 1). At night the signal " 6 N " has to be flashed by means of morse lamp.

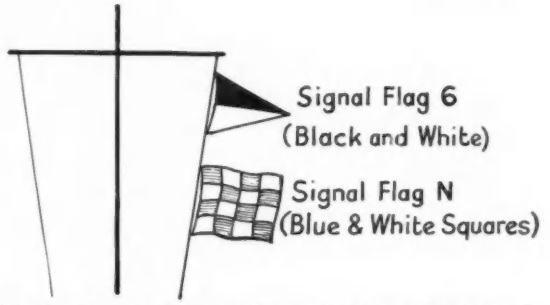
Since this condition appertains to the majority of all arriving ships, a large number could be sifted including those vessels not necessitating an immediate visit of one of our Health Inspectors.

At present this kind of signalling communication is on a voluntary basis and is introduced in the Federal Republic of Germany solely in the Port of Hamburg. It is a fact, however, that about 50% of all ships are making use of this system, thus supporting my view that shipping companies, as well as ships' navigators regard this arrangement as an improvement on former methods. Of course, this transmission is free of charge, as the port is deriving benefit from this system.

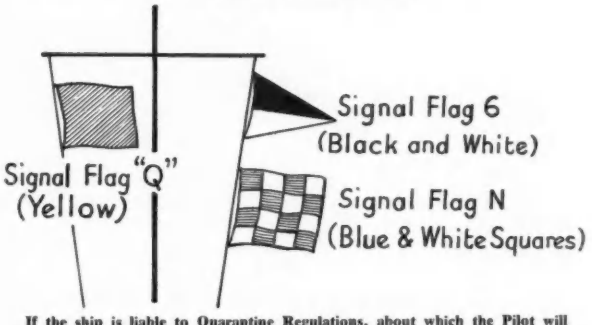
Everything has been done to make known the introduction of the method. Special instructions for captains of all ships destined

for the Port of Hamburg have been printed and detailed explanations have been submitted to all shipping companies and shipbrokers in Hamburg in order to make them acquainted with the scheme. Pilots and other port authorities have been asked for their assistance with a view to advising ships' navigators and the printed instructions have been sent to German shipping companies and to those companies abroad whose ships are bound for Hamburg. Finally, all pilots keep these instructions in readiness while boarding a ship at ELBE I, in order to give advice during the journey from ELBE I to Cuxhaven.

When I stated that about 50% of all ships bound for Hamburg are making use of this reporting system, I would point out firstly, that the employment of the system is quite voluntary, secondly, that in shipping traffic all innovations require some time to succeed, and thirdly, many ships bound for Hamburg come via Kiel Canal. In addition, masters of a large number of ships travelling



If all the answers to the six questions on the Maritime Declaration of Health are "No," the above signal must be hoisted at Cuxhaven and taken down immediately afterwards.



If the ship is liable to Quarantine Regulations, about which the Pilot will inform the Master, the above signal must be hoisted all the way to Hamburg and until the vessel is boarded by the Port Health Service.

Fig. 1. Signals for all ships passing Cuxhaven Signal Station for Hamburg.

within the national boundaries often endeavour to escape supervision without having rendered information with regard to health conditions on board their ships.

Most likely this will change in the near future. Influential German shipping companies, and more especially the Ministry of Transport, have recognised and accepted the advantages of the system which, during the past two years has brought satisfactory results. The intention is to publish regulations which would make it compulsory for all seaports within the Federal Republic of Germany to employ the system, and it is planned to extend its application even further.

When one or more questions of the Maritime Declaration Form of Health have to be answered in the affirmative the Ministry of Transport will provide for this case the hoisting of flag signal "C" in accordance with the International Code Book and which stands for "Yes." Once this position is achieved we shall know many hours in advance whether an immediate attendance of an incoming ship is necessary, or if the clearance may be placed on the waiting list.

Finally, those ships restricted to quarantine regulations, which are classified similarly to those in England, also come under the system but they, of course, will hoist the quarantine flag which should not be taken down until permission is granted by a Port Medical Officer after boarding the ship. However, should a ship restricted by quarantine regulations submit an "all well" declaration of health by radio, or, in the required manner, via the signal station at Cuxhaven, the Port Health Service in Hamburg may and will generally issue a preliminary free pratique in good time to allow the ship on its arrival to commence work without having to wait for the usual Port Health formalities. In such a case the first port official boarding the ship will give permission to the captain to take down the flag.

I would emphasize once again the decisive advantage of this system which is shown by the fact that we are in a position not only to lay hold of Q-ships but also to seize those ships carrying endemical infectious diseases occurring in Germany. I think it can be said that all infections of importance carry symptoms specified in the Maritime Declaration of Health, thus forcing ships' navigators to follow instruction by informing us in time for necessary action to be taken before there is a possibility of the crew getting in contact with the shore. This practice will prove to be the same as prohibiting Q-ships unrestricted communication, with the difference, that, by this system, no delay or curtailment of work is caused to a ship. Also, it is expected that the system will help to release valuable labour, as soon as it becomes compulsory within the Federal Republic of Germany for all masters of ships to comply with these regulations.

As stated in the beginning, my office is also responsible for a number of other important tasks which I should like to briefly mention.

The subjects of Port Hygiene and rat infestation and rat control do not require special consideration as the basic principles in both our countries are alike and, therefore, commonly known.

Much work, however, is caused by ships' dispensaries and hospitals. Since these duties are carried out in a different manner in your country, may I be permitted briefly to mention this subject.

According to German law, the medicines and medical stores, as well as the equipment of hospitals on German merchant ships, are supposed to undergo an official annual check. Every German ship must be in a position to furnish proof of that annual check by means of a certificate. Checking, as well as the issue of this certificate is a responsibility of the Port Health Service.

The equipment with regard to quantity, kind of medicines and implements to be carried, are laid down by law as precisely in Germany as in your country but, in the long run, all well-intentioned legal regulations will prove to be unsuccessful if not applied with understanding, especially in the case of tasks unfamiliar to those responsible for ships' construction and equipment. There remains much to be done for all medical officers of the Public Health Service in the Federal Republic to render advice and to suggest improvements. In contrast to your country there are only a few shipping companies in Germany—actually not more than two—which have appointed a medical practitioner to their permanent staff who could take an interest in this matter. The remainder leave the planning of a ship's hospital and the location of the medicine chest and equipment to a layman who may not treat this matter as one of primary importance. We try to keep in contact in an advisory capacity with all ship yards of influence and good results have been obtained in co-operation with constructors and shipping companies.

A similar situation applies to the ships' crew. They hold on board an excellent and up-to-date equipment of medicines and medical stores, but who of the ships' officers can spare the time or is prepared to become fully conversant with this equipment

which, however, is necessary for its most advantageous use ? During the annual routine inspection of a ship's dispensary we are less interested in carrying out a check on the exact quantity of medical stores and equipment, because the supplier, with a profit motive in view, can be relied upon to keep the equipment fully stocked. Most of our interest is directed towards fully discussing medical treatment and the best use of the available equipment, with the appropriate ship's officer, on the basis of entries made in the sick report book. Quite frequently we are faced with the necessity of breaking through a barrier of objections. Often an official is regarded simply as a controller but, unfortunately, not as an adviser and assistant. Once, however, these objections have been overcome, ships' officers will reveal an extensive field where medical officers can offer beneficial and productive advice.

The matter of crew's accommodation is also a responsibility of the Port Health Service in the Federal Republic of Germany and, considering that prevention is better than cure, these duties are not merely of a supervisory but also of an advisory nature. All German ships must be in possession of a certificate stating that an inspection of the crew's accommodation has been carried out and found to be up-to-date in accordance with legal regulations. This certificate expires after three years and must be renewed.

Unfortunately, the supervision of imported food supplies is not our responsibility. These duties are distributed amongst several other authorities.

I presume that in your country, as in mine, all emigrants are bound to undergo a medical examination since the receiving country will demand a Bill of Health. In the Federal Republic the carrying out of necessary medical examinations, the medical care and control of emigration transports, as well as the inspection of emigration ships, are the responsibity of the Port Health Service, and there are at our disposal special treatment and consulting rooms with up-to-date equipment including an efficient X-Ray apparatus.

Harbour Works at Bermagui, Australia

New Breakwater and Training Walls*

The Department of Public Works, New South Wales, Australia, has recently completed construction of a small fishing boat harbour in the Bermagui River on the South Coast of N.S.W. Bermagui is an important fishing centre, particularly for Tuna fishing, and the Bermagui River, although unsatisfactory, has been used as a fishing harbour for many years.

Apart from the dredging of an anchorage basin and the construction of a small jetty in 1936, the river had remained in its natural state until the improvement works started in April, 1958. Although the river provided a safe anchorage, entry was difficult because of bad channel alignment and a shallow bar. Vessels frequently were restricted to entry at high tide. The entrance channel originally ran in a north-westerly direction after leaving a rocky headland and reef to the east (see accompanying plan). Vessels entering the river either had to use the channel, which meant moving parallel to the wave fronts, or else closely skirt the reef and cross a shallow shoal.

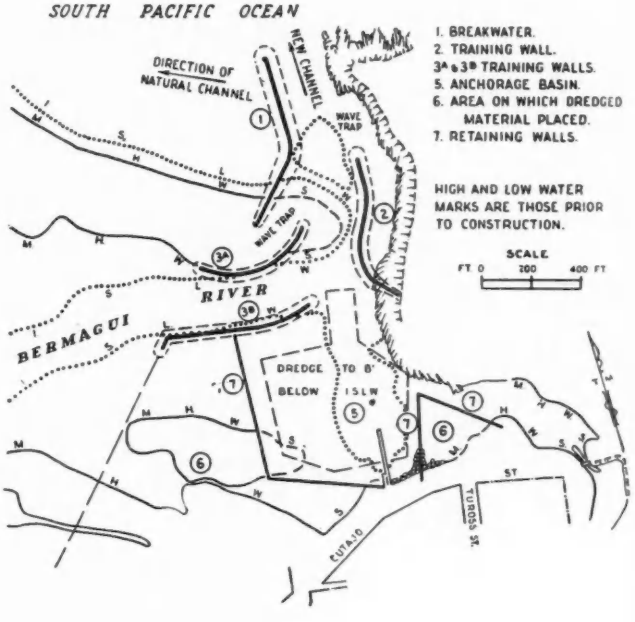
Works to improve the harbour consist of a breakwater 730-ft. long, three training walls of total length 1,980-ft., 1,810-ft. of reclamation walls and a dredged anchorage basin approximately 600-ft. by 600-ft.

The purpose of the breakwater is to direct the entrance channel to the north and more nearly at right angles to local wave fronts. It also confines the tidal flow against the reef to provide a permanent depth of six feet below Indian Springs Low Water. It is also expected to reduce movement of marine sand into the river. (The entrance depth depends almost entirely on tidal flow as the Bermagui River has a small catchment and few floods or freshes.)

The eastern training wall which is roughly parallel to the headland provides a better channel alignment inside the entrance and moves it away from the dangerous rocky foreshores. The two other training walls are to stabilise the river channel and deflect moving sand away from the anchorage basin. The gaps between breakwater and training wall and training wall and headland serve as wave traps to reduce disturbance in the anchorage.

The anchorage basin is dredged to a depth of 8-ft. below I.S.L.W. and the dredged material was used to reclaim adjacent tidal flats for use as harbour access areas and recreation reserves. The reclamation west of the basin also served to stop tidal flow through the basin and resultant siltation.

*Abstract from the Journal of the Institûtion of Engineers, Australia, April/May 1960.



The breakwater and training wall are of tipped stone, the maximum size used being six tons at the outer end of the breakwater. Granite was obtained from a quarry opened for the works at Central Tilba, twelve miles from Bermagui. Transport of stone was by lorry direct from quarry to walls. Dredging was carried out under contract by the Hunter River Shell and Dredging Company. The total quantity dredged was 85,700 cubic yards *in situ*.

Although it may be two or three years before the final result of the works can be seen, results to date have been pleasing and more than hoped for. The channel so far has been from 8 to 12-ft. below I.S.L.W. and has been workable at all stages of the tide. Up to date no bar has formed outside the entrance and successful entry has been made under severe storm conditions which previously would have made the entrance impossible. The anchorage has been found to be almost entirely unaffected by wave action, the reduced waves that pass the wave traps being deflected up river.

The harbour was officially opened by the Minister for Public Works in November, 1959.

A Model Investigation into the Possibility of a New Approach Channel to Southampton Water

By N. B. WEBBER, B.Sc.(Eng.), A.M.I.C.E., A.M.I.Struct.E., and T. L. SHAW, B.Sc.(Eng.).

Introduction

The main shipping lane to Southampton is via Spithead and the East Solent. The alternative approach via the West Solent is only of limited value, since the tidal range and depths are much less than those given via Spithead; further unfavourable features are the fast tidal streams in the Hurst Narrows and mobile shoals off the Needles Channel.

Owing to the shallows in the vicinity of the Brambles Bank, all vessels, except small coasters, use the Western Approach Channel (Fig. 1), which runs parallel to the coastline in a south-westerly direction from Calshot. This is a natural channel produced by tidal scour, although a limited amount of improvement dredging has been carried out. Little or no maintenance dredging is required, and in fact this stability of regime is a happy feature of almost all the Solent waterways.

For all sizeable vessels the present approach requires a 4,000-ft. radius turn to starboard into the Western Approach Channel from the East Solent (involving a 110 degree total alteration in course) and a further 4,000-ft. radius turn to port round Calshot Spit (involving a 75 degree total alteration in course). The suggestion, therefore, has from time to time been made that a more direct approach from the East Solent would be desirable, and indeed possible, if the North Channel, which is aligned roughly in the direction of the tidal stream towards Spithead, were deepened. The new approach lane would then be located in an almost straight line between a junction with the existing deep channel to the northward of Ryde Middle Shoal and the entry to Southampton Water. As indicated in Fig. 1 a dredged channel some 5,000 yards in length would be entailed.

Before embarking on a project of this magnitude (the cost is not easy to assess from present data, but would probably be of the order of £5 million) both its feasibility and economic worthwhileness would need to be thoroughly established. The navigational characteristics of the new channel would be of extreme importance and the availability at Southampton University of a hydraulic model has enabled this aspect to be investigated. Details of the investigation are briefly outlined in the present article.

Details of Model

The model was initially constructed for the investigation of certain dredging works proposed in connection with the Caltex oil refinery scheme in Southampton Water. Its construction and operation have been fully described elsewhere* and space permits only the barest details to be quoted here.

The model is of the fixed bed type and covers the entire Solent area, extending from Ryde-Gilkicker in the east to Hurst Narrows in the west. The dimensional scales are 1 : 1,250 horizontally and 1 : 100 vertically. In accordance with the model laws, the velocity scale is 1 : 10 and the time scale 1 : 125.

The two points of tidal access have made calibration of the model a difficult problem and at present it is only equipped for a repetitive spring tide. This condition is suited to investigations where maximum tidal currents are the primary consideration.

*Wright, W. and Leonard, R. D., "An investigation of the effects of a proposed dredging scheme in Southampton Water by means of a hydraulic model," Proc. Inst. C.E., Vol. 14, Sept. 1959, p. 1.

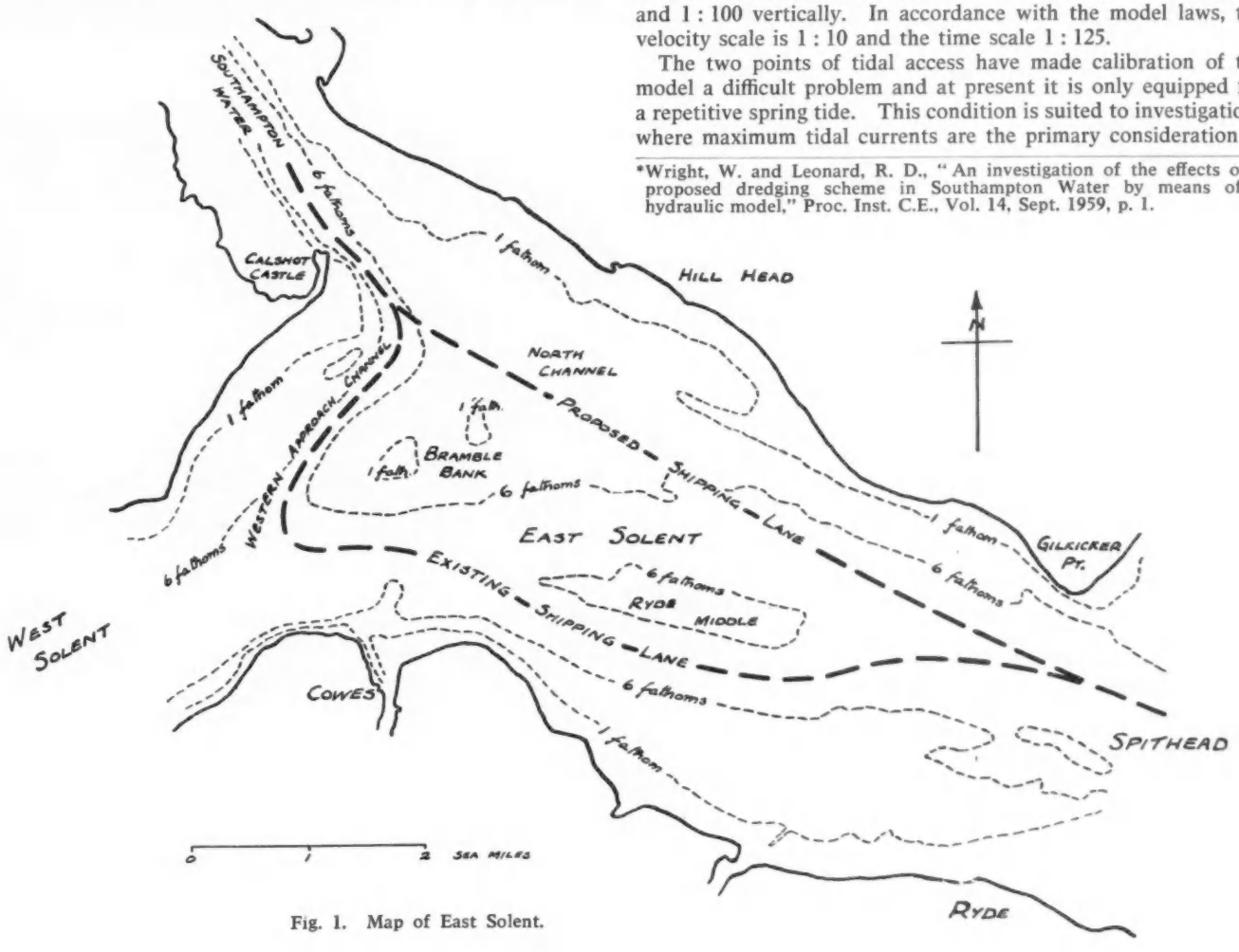


Fig. 1. Map of East Solent.

Channel Design

The Western Approach Channel has a minimum water depth of 38-ft. at L.W.O.S.T. It was considered that the new channel should be 2-ft. deeper, namely 40-ft. at L.W.O.S.T., so as to accommodate vessels of a slightly greater draught in the future. This depth standard would enable all vessels, except the "Queens" and the largest oil tankers, to enter and leave the port at all states of the tide.

The minimum bed width of 1,000-ft. in the Western Approach Channel has proved quite satisfactory and this width was adopted for the proposed new channel. The average depth of cut was found to be about 20-ft. and in order to ensure lateral stability side-slopes 3 to 1 and a 50-ft. wide berm at a height of 10-ft. above the bed were considered desirable. Fig. 2 shows the channel cross-section and Figs. 3 and 4 are views of the channel as it appeared in the model. The vertical hardboard strips are training walls and their purpose is explained later.

Transverse Currents

From the navigational point of view it is the transverse component of the tidal stream which constitutes the greatest hazard. For instance, on the assumption that vessels would proceed at 10 knots along the new channel, a transverse current of 0.5 knot

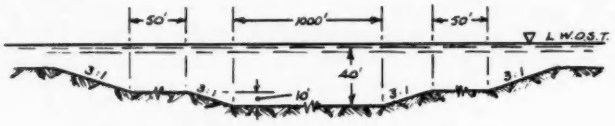


Fig. 2. Cross-section of proposed channel.

would entail a deviation of about 3 degrees and a 1-knot current a deviation of about 6 degrees. Particularly objectionable would be a transverse current which varied sensibly along the length of a vessel, and it is relevant to point out that several of the vessels proceeding to Southampton Water are in the region of 1,000-ft. long.

Investigation Procedure

Prior to the introduction of the new channel in the model, observations of tidal level and current velocity and direction were made at a number of points. Comparison with prototype data confirmed that there was reasonable model-prototype conformity in the area concerned. After the new channel had been cut and moulded to shape, observations were again taken. As might perhaps be expected, only minor changes were discerned.

The model results indicated maximum transverse velocities over the entire length of the channel in accordance with the curve shown in Fig. 5. It was evident that at the south-easterly end entry conditions were quite reasonable and even up to a point within about 1,200 yards of the Western Approach Channel the maximum transverse velocities were less than 0.7 knot. There was then a progressive increase to a maximum of 1.1 knot at the intersection point. In this vicinity the maximum variation in transverse velocity per 1,000-ft. was approximately 0.4 knot, occurring just after the time of low water. When considering the implications of these data it is important to remember that there would be a greater width available for manœuvring at the north-easterly junction point; also, that the velocities referred to were maximum velocities and that, for by far the greater part of the tidal cycle, conditions were much more favourable.

The possibility of mitigating these transverse currents by means of training walls was investigated. This was done more as a matter of interest than as a likely practical proposition, since it is quite evident that not only would they greatly add to the capital cost, but also their presence would be viewed with disfavour by the pilots of large vessels and by the many yachtsmen who cherish these waters. Several alternative training wall systems, raised to H.W.O.S.T., were tested in the model. Fig. 6 shows the one which gave the best results. With this system transverse currents were almost completely eliminated over the entire length of the new channel, but at the north-westerly end an increase near the time of low water was unavoidable. The maximum longitudinal current in the new channel was 1.6 knots, occurring at 1 hour after high water.

Fig. 3. Cut-off channel in model, looking towards Southampton Water.

Fig. 4. Calshot Junction in model, looking towards Spithead.

Velocities in the model were mostly measured by means of a miniature current meter linked to a dekatron counter. A photographic technique was also adopted. This consisted of photographing the position of small floats at successive intervals of time, superimposing on one negative. As shown in Fig. 7 a series of dots were obtained which gave a good visual indication of the direction of the tidal stream; also, knowing the shutter interval, the velocities could be ascertained.

General Comment

The model investigation demonstrated the difficulties associated with an artificial channel in estuarine waters which has an alignment contrary to the direction of the dominant tidal stream. Transverse currents are objectionable on navigational grounds

and in the present scheme they could not be eliminated. If a maximum transverse current of 0.5 knot were acceptable, then the model (without training walls) indicated that the channel would be navigable for about 65 per cent of the spring tidal cycle. Conditions during neap tides are not known, but there is every likelihood that they would be more favourable.

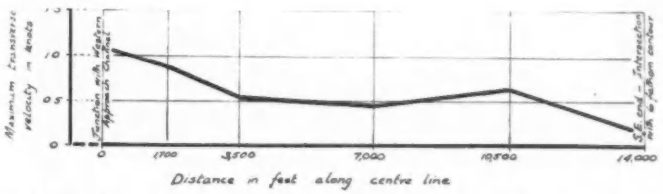


Fig. 5. Curve showing maximum transverse velocity along proposed channel.

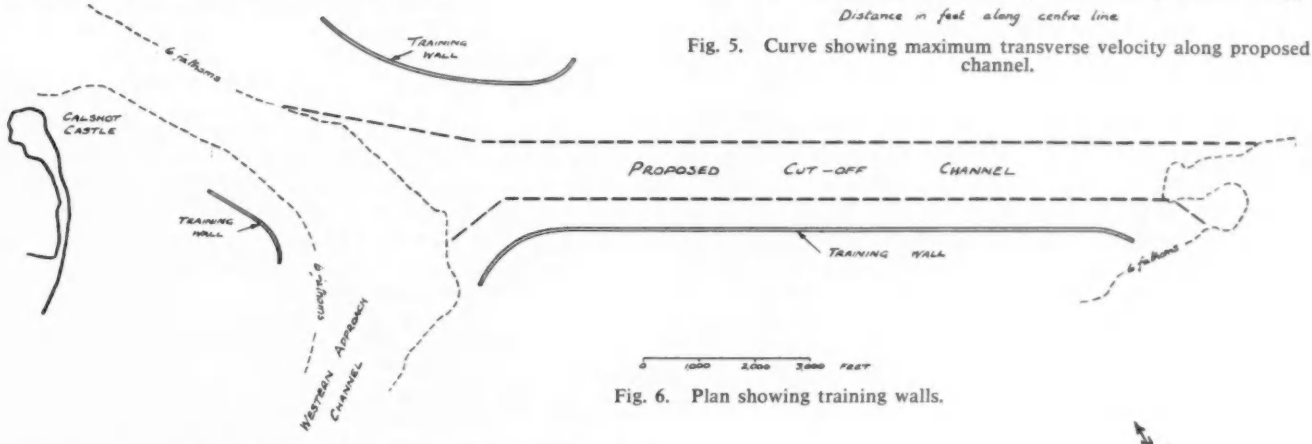


Fig. 6. Plan showing training walls.

Also, but beyond the scope of the present investigation, there is the important question of channel maintenance. The bed of the East Solent is remarkably stable, but the nature of the material through which the new channel would be cut can only be conjectured at the present time. Any tendency towards instability of the side slopes could lead to troublesome shoaling in the dredged channel and also possibly in the existing natural channel. Thus, should further consideration be given to this project, it would be necessary at an early stage to make careful analysis of the sub-strata as revealed by a comprehensive set of marine borings.

In conclusion, the authors wish to express their indebtedness to Commander D. H. Macmillan, M.B.E., R.N.R., F.R.I.C.S., Hydrographic Surveyor to the Southampton Harbour Board, for his helpful suggestions concerning the alignment and cross-section of the proposed channel, and also for his encouragement in the investigation. He is not, of course, responsible for any opinions expressed in the article, which are those of the authors.

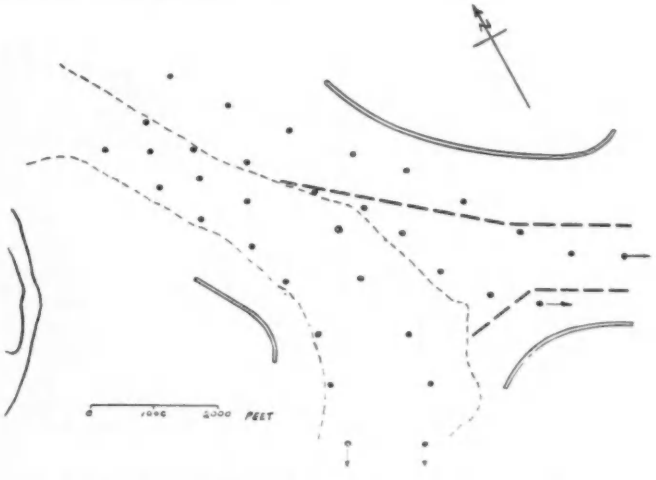


Fig. 7. Photographic tracking of floats at Calshot Junction.

Gravity Fenders at Angle Bay, Milford Haven

The deep water terminal for tankers now under construction for B.P. Trading Limited at Angle Bay, Milford Haven will contain two berths, either of which will accommodate super tankers of 100,000 tons d.w.t. in 54-ft. of water.

Owing to the exceptional site conditions the jetty strong points have been designed as gravity structures in mass concrete founded on rock, thus the problem of fendering required careful attention. The duties of the fenders are two-fold, firstly they must absorb the berthing impact in such a way that the forces on the vessel and on the jetty are reduced to the minimum and, secondly, vessels must be able to lie safely alongside the jetties under all weather conditions likely to be experienced on the Haven. Although the site at Milford Haven was chosen because it is a sheltered inlet, this latter point is very important when maximum availability throughout the year is required from a jetty in this great depth of water.

These conditions, together with the wide range of tide in the Haven, led to the use of gravity fenders consisting of 100-ton weights hanging in groups of four on the face of the jetties. Each weight hangs on two pairs of links arranged so that when it makes contact with the side of the vessel it is pushed backwards and upwards into a recess in the face of the jetty. To cover the full tidal range the weights are 24-ft. deep. A fender group consists of four 100-ton weights and two fender groups are provided at each of the two jetties, making a total of sixteen gravity fenders in all.

It will be appreciated that the total mass of all the fenders in any one berth is a very small fraction of the mass of the ship that has to be brought to rest. The energy of the vessel is absorbed by the lifting of the weights, a rise of 3-ft. 6-in. corresponding to the maximum horizontal travel of 5-ft. Some idea of the resilience of the system may be gained from the fact that a force of 25 tons will move a weight 2-ft. horizontally, 80 tons are required for 4-ft. and about 200 tons for the maximum travel of 5-ft. The fenders as a whole are designed to absorb the energy of a 100,000 ton d.w.t. vessel moving at a speed of four-fifths of a foot per second at right angles to the face of the jetty. Ample strength is allowed to counter forces set up by vessels berthing with slight way ahead or astern.

Construction of the fenders is in steel, the weights consisting

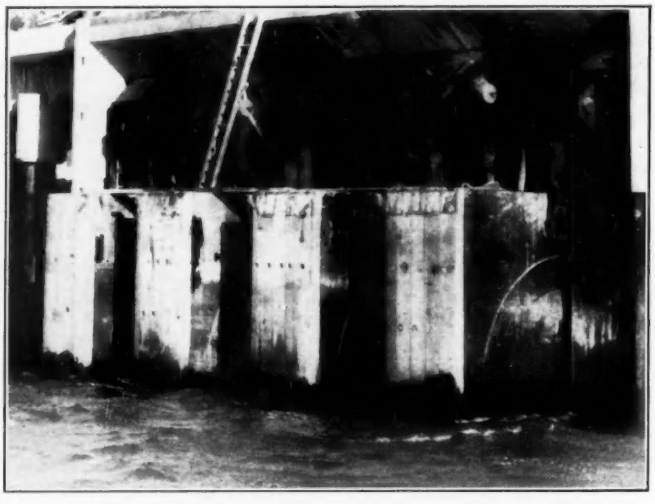


Fig. 1. Fender group in position at end of jetty.

of boxes measuring 24-ft. x 13-ft. x 4-ft. 6-in. in half-inch steel plate filled with concrete after erection. The four weights of each group hang in a steel framework set in the jetty face. This framework is of stout construction to resist the high forces involved and consists of 3-ft. square steel box columns set in concrete at the bases, filled with concrete after erection and strutted back to the rear face of the recess with heavy H-section struts. Guide plates on the struts and the columns limit the sideways movement of the weights to a quarter of an inch either way. Fine clearances in a structure of this size require very close tolerances in manufacture and particular care was needed to maintain the dimensions of the weight boxes during fabrication and filling with concrete. Welding is used throughout, all trunnions, brackets, baseplates, etc., are built up from plate, no castings being used. Bolting is used only where parts such as trunnion pins, links and rubbing guides must be capable of replacement and in most cases bolts are of high strength steel jacked to a predetermined tension. Trunnion pins are in high tensile rust resisting steel and the material generally is welding quality high tensile steel. Greenheart timbers are bolted to the front faces of the fender boxes, anti-corrosion protection is achieved by painting all underwater steelwork with Epimastic epoxy resin based paint.

The illustration (Fig. 1) shows one fender group in position at the end of the jetty. The columns, weights and upper links are clearly visible, the lower links are below water level. In the rest position the weights are held back from bottom dead centre by a set of four rubber sleeved stop pins bearing on the backs of the columns. This preloading of the weights prevents minor wave action causing continual oscillation.

The mass concrete berthing dolphins carrying the fenders were constructed within sheet piled cofferdams which remain permanently in position. Sufficient room was available within the cofferdams for the fender columns to be placed and secured in the dry but this was not possible with the hanging weights. The sections of sheet piling in front of the fender recesses were removed and the empty casings of the weights placed by floating crane, this part of the work being carried out between tides. After all the trunnions and links had been secured the weights were filled with concrete to bring the weight up to the 100 tons required.

Considerable attention has been given to providing ease of maintenance. Equipment is provided to retract any one or more weights fully into the fender recess in the jetty where they can be suspended from eyes cast in the concrete deck. When this has been done links and trunnion pins can easily be removed for repair or replacement and timbers, rubbing guides, etc. can be replaced without putting the berth out of action. Retraction of a weight is effected by attaching to it a pair of long links which pass upwards through the jetty deck. A baseplate and cross head are fitted over the links which are then jacked up by two hydraulic jacks working in 12-in. stages.

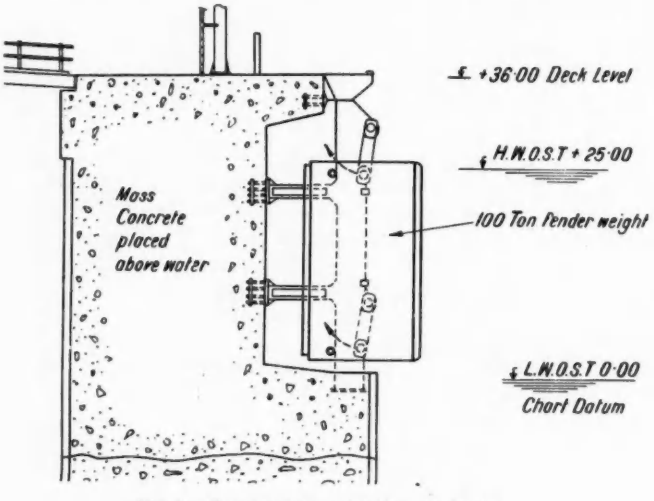


Fig 2. Cross-section of jetty and fender.

Fig. 3. Aerial view of the new jetties at Angle Bay.

The fenders were designed by Rendel, Palmer and Tritton, consulting engineers to BP Trading Ltd. for the jetties and were manufactured by Weldall and Assembly Ltd., Stourbridge. Erection on site was carried out by Weldall and Assembly Ltd. in conjunction with Christiani and Nielsen Ltd., main contractors for the jetties.

Trade at the Port of Sydney

According to a recent announcement by the Sydney Maritime Board, a record number of both ships and cargo was handled at the port of Sydney during the year ended June 30, 1960. The total trade handled was 9,729,966 tons, which shows an increase of 1,200,000 tons compared with the previous year. The gross tonnage of vessels using Sydney was 20,895,991 tons, representing an increase of 2,000,000 gross tons. (These figures excluded Botany Bay.)

The increase in cargo tonnage was accounted for mainly in the overseas trade, export figures showing an increase of 750,000 tons and overseas imports 580,000 tons. Exports of wheat, flour, wool, coal and imports of oil, chemicals, timber, vehicles and paper all increased substantially.

The Work of the Shipping and Forwarding Agent

By D. I. HEYS
Vice-Chairman, Foreign Relations Committee,
The Institute of Shipping and Forwarding Agents

Any attempt to crystallise the duties undertaken by the Shipping and Forwarding Agent and to describe in one simple sentence the services he renders is quite outside the realms of possibility; his activities on behalf of British (and indeed International) industry and commerce, are now so diverse and complicated that any brief description must fail in its purpose.

The forwarding agent's role in matters of transport, be it by sea, air or land, is to have the knowledge, based on long experience, to advise his clients with accuracy and precision how best their products (which could easily range from raw materials to giant electric generators or locomotives) can be safely and economically lifted and transported from one point to another, either within the confines of these islands or to some far distant and frequently almost inaccessible destination in a little known part of the world where communications are poor and where special arrangements and planning would be necessary to ensure safe discharge from carrying vessel and also final delivery to destination.

The responsibilities of the forwarding agent have increased considerably in the last fifteen years. In the pre-1939 era the export trade of the United Kingdom could be said to be in the hands of certain clearly defined traditional exporting industries; these were the days of the mighty British Empire and Commonwealth, where much of our export trade was concentrated and from which we received our imports of raw materials and food. The British pound was supreme and freely convertible, and was acceptable anywhere in the world, exchange control difficulties and import licences being virtually unknown.

Britain having dissipated all her wealth and treasure in the defence of the free world emerged in 1945 to find (1) that she no longer enjoyed her pre-eminent trading position ; (2) that her money was no longer the much sought after currency it had been in the past and (3) that international trade could only be concluded under the frustrating difficulties of rigorous exchange control regulations and export and import licence restrictions.

Whilst it is true that some of these problems have been reduced in severity and in some cases removed, the comparatively simple trading methods of pre-war days are no longer with us and the pitfalls that lie in the path of the inexperienced exporter or importer are legion.

" Letters of Credit " framed in ambiguous and seemingly impossible terms and which are the subject of unyielding literal translation by banks have become more and more a feature of trading relationships, as have the requirements of foreign Governments that goods purchased in the United Kingdom should only be carried in vessels flying their own flag or that a certificate should be provided visaed by their consular staff declaring that the vessel during its voyage or voyages will not (and in some cases never has) call at a port of a nation with whom they are at variance.

These are but a sample of the many problems on which a forwarding agent is expected to have a ready answer when asked by his shippers, and to fulfil this aspect of the service he has to offer, it is necessary for him to have at least some of the qualities and knowledge usually associated with bankers, lawyers and others who normally specialise in a particular professional or commercial field.

As normal day to day routine the forwarding agent provides information covering the most advantageous routing of goods to ensure quick delivery, most favourable freight rates to be applied, advice on packing and suitable types of stowage in addition to ensuring that the correct consular documents, where necessary, are provided; he also disburses freight and port charges on behalf of his regular or other approved shippers.

Many forwarding agents operate transport fleets and are able to collect or deliver consignments to and from any point in the United Kingdom; many have extensive packing facilities where consignments may be packed on behalf of shippers, employing the most modern up-to-date techniques. Exhibits for foreign trade exhibitions are almost exclusively packed, shipped to destination, set up on their stands and finally dismantled and returned to the exhibitors' premises by forwarding agents.

Recently a consortium of three agents has been formed to undertake these highly specialised duties in connection with an exhibition of British goods in Moscow in 1961 which poses special problems in that details of transport conditions within the Soviet Union are not readily available.

Packing of furniture, antiques and art treasures either in tailor-made cases or by lift vans for delivery in any part of the world is also a very important part of these agents' services.

Warehousing forms a very important part of the activities of the more specialised forwarding agents and many millions of tons of a wide variety of commodities and raw materials pass through their hands yearly.

Consignments arriving from overseas are cleared through H.M. Customs, inspected and weighed on landing and delivered into store where they may be broken down into smaller lots or repacked into containers suitable for the home trade, and finally delivered to the consumer or user in Great Britain.

Commodities which attract a high rate of duty may be held in bonded warehouse until such time as they are required, in which case duty is only payable as and when consignments are removed from storage.

Many forwarding agents, through historical connections or by the natural evolution of their business, have tended to specialise in one particular market, trade or commodity. This is particularly so in London where we find agents with strong Continental attachments, and in Liverpool where relationships with Canada and United States of America are mostly centred.

These specialised agents have offices or correspondents in these territories which enable them to offer most comprehensive services including the delivery of consignments both large and small to interior destinations, and in many instances banking and C.O.D. collections.

The forwarding agent who specialises in the movement of merchandise between the United Kingdom and the Continent of Europe is faced with different problems from the normal " deep sea" agents, as apart from the short sea journey across the channel his responsibilities are, in the main, concerned with delivery to interior destinations which call for movement across several land frontiers and involve not only a vast knowledge of the European transport system, but also a thorough acquaintance with Customs requirements and procedures in all Continental countries.

The Continental agents offer several routes by which goods may be delivered to any point in free Europe, by through ferry/rail truck loaded and controlled by themselves; by sea to Continental port and thence by rail, road or barge to final destination; by air and now by the increasing use of road trailers which may be loaded at assembly or manufacturing point in the United Kingdom and delivered direct to consignee in Europe. This latter form of transport is not only confined to dry cargo but extends to liquids in bulk as tanker trailers are now crossing the channel to Continental countries daily.

In all probability the most dramatic and spectacular increase in the carriage of freight in recent years has been by air and without doubt the forwarding agent has made a considerable contribution to this increase. Many agents who specialise in this traffic

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Austria's Trade on the River Danube

Appreciable Increase in Foreign Traffic

There are signs of a revival of international traffic on the lower reaches of the Danube. For 15 years this trade has been almost completely stagnant but now Austria has to decide whether or not to accept Russia's invitation to join the Belgrade Danube Commission. The U.S.S.R. has placed an order with the Danube Shipping Company for the transportation of 220,000 tons of coke and iron ore from Linz in Upper Austria to Ismail, the former Rumanian and now Russian port on the estuary of the Danube.

Austria has always looked upon the Danube as a lifeline. This land-locked state, like Czechoslovakia and Hungary, depends upon the co-operation of its immediate neighbours for its means of communication with the outside world. Despite the widely differing political and cultural outlook which has often separated them, the countries along the banks of the Danube have always had a tacit agreement not to do anything to obstruct international traffic on the river—an agreement which has seldom been broken. Not only was traffic along the Danube the most easy and natural means of communication between these countries but it became an integral part in the economic life of the countries of South East Europe. The unrestricted flow of traffic along the Danube led to the economies of individual nations developing so as to complement one another and was as essential to the predominantly agrarian countries in the East for the efficient functioning of their economies as it was to the industries of Austria and Bohemia.

As a result of the disintegration of the Austro-Hungarian Empire, the Danube was policed in inter-war years by members of the International Danube Commission, which included Britain, France and Italy, as well as the riparian states. The great bulk of the international traffic was handled by the First Austrian Danube Shipping Company and most of the company's vessels were still afloat at the end of the second World War. Since they were concentrated between Linz and Regensburg they came under American control and it was not until 1952 that all the company's

vessels were able to travel unrestricted past the inter-zonal frontier at Linz. Before then licences were granted by the Soviet authorities to individual vessels to operate as far down as Vienna.

In 1948 the Russians set up a new Danube Commission confined to the riparian states. This gave the Soviet Union virtual control of the Danube all the way down to the Black Sea, but it is a hopeful sign for the future resumption of traffic on the river that even when the Soviet and Yugoslavia were involved in a bitter dispute, neither side interfered with the vessels of the other.

Although no obstacles have been placed in the way of Austria sending its ships downstream, there has up to now been almost complete stagnation of traffic on the lqwer Danube. One of the main reasons for this is that the agrarian countries have as yet no surplus of grain to export to the West and no foreign earnings for the purchase of imports. There is, therefore, no trade at the moment to attract Austrian shipping.

On the Austrian stretch of the river however, the recovery of trade since the signing of the peace treaty in 1954 has been quite dramatic. Internal traffic has been increased by more than 600 per cent in the past five years and foreign traffic, which is almost entirely confined to trade with Western Germany, has gone up by 70 per cent. Although Austria now faces West economically —a trend which is reflected in the rise of Linz in the West to take Vienna's place as leading Danube port—the situation is a highly artificial one since it does not take into account the national and traditional economic links which Austria has with the lower Danube countries.

Austria's present trade with the West depends largely on a system of preferential freight charges devised by Federal Germany to attract Austrian export and import traffic, a factor which serves to underline the artificiality of the present situation. These preferences enable goods coming from Graz on Austria's frontier with Yugoslavia to be carried within Germany at lower mileage rates than goods from upper Austria. In this way it is often made cheaper for Austrian merchants to send their goods by the long way round by way of Hamburg rather than via Trieste, which is only a quarter of the distance.

The Russians in their concern for a revival of the traditional trade between Austria and the lower Danube states, now integrated in the Soviet Union have, however, first to overcome the problem of the shortage of goods to trade in before a lively traffic can be restored.

The Shipping and Forwarding Agent—*continued*

have offices at all principla airports which operate on a twenty-four hour basis to ensure rapid clearance and distribution.

As explained in the opening paragraphs the foregoing is only a general outline of the very comprehensive and extremely varied activities of the forwarding agent in the busy world of the international exchange of goods where speed, economy and first-class service are the prime essentials. Much of his work is routine but supremely interesting, and new methods are a constant challenge to his abilities.

Mention has not been made of marine insurance, a market in which the forwarding agent has a very substantial interest. Chartering and brokerage, both sea and air, have also been omitted as have stevedoring and master porterage. These services, although in daily use by the agents are activities in their own right.

It is the forwarding agent's constant endeavour to improve the services he has to offer and much time and energy is devoted to this end. Whilst the war was still raging the nucleus of a national organisation was formed by leading members of the profession, and now " The Institute of Shipping and Forwarding Agents " based on strong local branches under the leadership of a National Council has brought substantial and lasting benefits to its members.

In addition to regulating professional behaviour within its membership and defining " Trading Conditions " under which the agents conduct their business, it provides educational facilities for student members to improve their knowledge and present themselves for examination to become "Associates," or "Fellows."

The Institute is now recognised by Government departments, port authorities, and other interested organisations as a full negotiating body on all matters affecting the profession.

The forwarding agent still retains a ruggedly individualistic outlook in a sternly competitive field and undoubtedly his services continue to be of the greatest value to any exporter or importer.

Automatically Operated Floating Gate at the Port of Le Havre

Closing the Entrance to Oil Dock*

The Compagnie Industrielle Maritime is a concessionary company entrusted with the construction and operation of the oil harbour at the Port of Le Havre. Upwards of 10 million tons of oil were handled by the port in 1959. In addition to the facilities provided by the two existing oil docks, a third oil dock with two berths capable of accommodating 65,000-ton super-tankers was completed in 1955. As a safety precaution—to prevent a film of oil spreading over the surface of the water in the entire port area in the event of an accident—this dock, like the two others, has been provided with a movable floating gate for closing the entrance.

The first oil dock at Le Havre, which was constructed in 1925, is equipped with a gate formed of three pontoons connected end-to-end by means of chains. The second oil dock is equipped with a gate of similar design, but consisting of five pontoons, which was installed in 1932. Each of the pontoons is 32.40 m. in length and consists of a tubular steel hull (1.50 m. diameter) provided with a continuous horizontal diaphragm dividing it into two separate compartments and with a ballasted keel of rectagular section. The pontoons are manoeuvred and secured in position by a system of winches and anchoring devices. As Le Havre is a tidal port, the end pontoons of the gates are attached to the dock entrance pierheads by means of a sliding connection which permits the pontoons to rise and fall freely with the tide.

The gates of No. 1 and No. 2 dock are normally kept in the "closed" position. The dock entrance is opened only to allow vessels (tankers and auxiliary craft) to pass into or out of the dock. The process of opening or closing the gate is slow and laborious, taking about 70 or 80 minutes to accomplish and requiring the services of four men at the winches assisted by a 25 h.p. motor launch. It has the further serious disadvantage of being expensive in terms of annual operating costs.

For these reasons it was decided to adopt automatic operation for the gate of No. 3 dock. Competitive tenders were invited for the design and construction of a gate consisting of six pontoons joined together by articulated connections, the pontoons being so arranged as to form a zig-zag pattern (on plan) when the gate is closed and capable of being "folded back" in order to open the gate. The gate was to be operated by means of a submerged chain attached to

* Based on an article by F. Schlecht and J. Casteran in "TRAVAUX", No. 295, May, 1959.

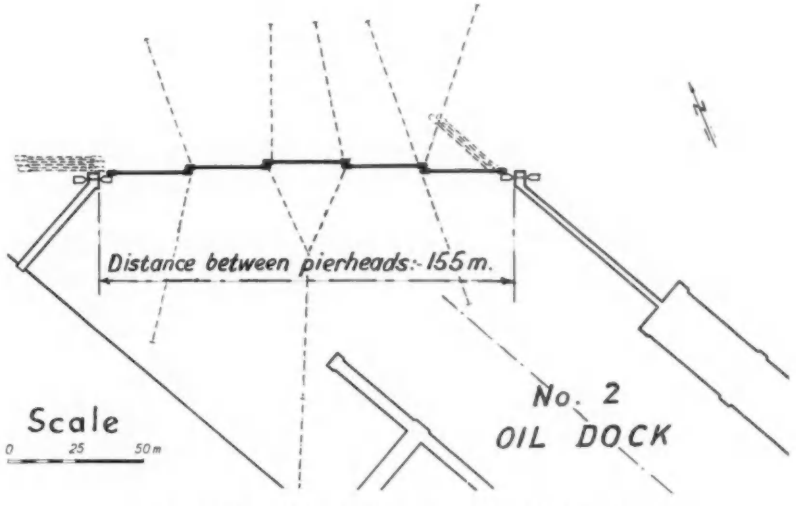


Fig. 1. Plan of the floating gate of No. 2 Oil Dock.

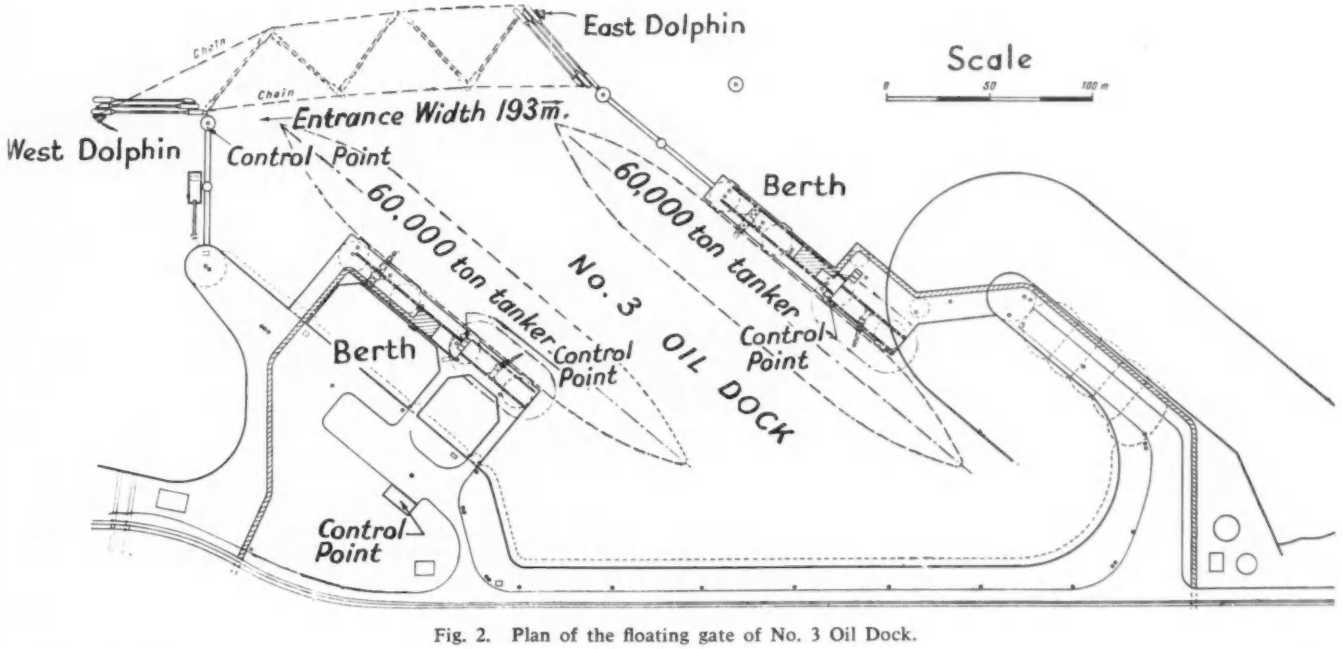


Fig. 2. Plan of the floating gate of No. 3 Oil Dock.

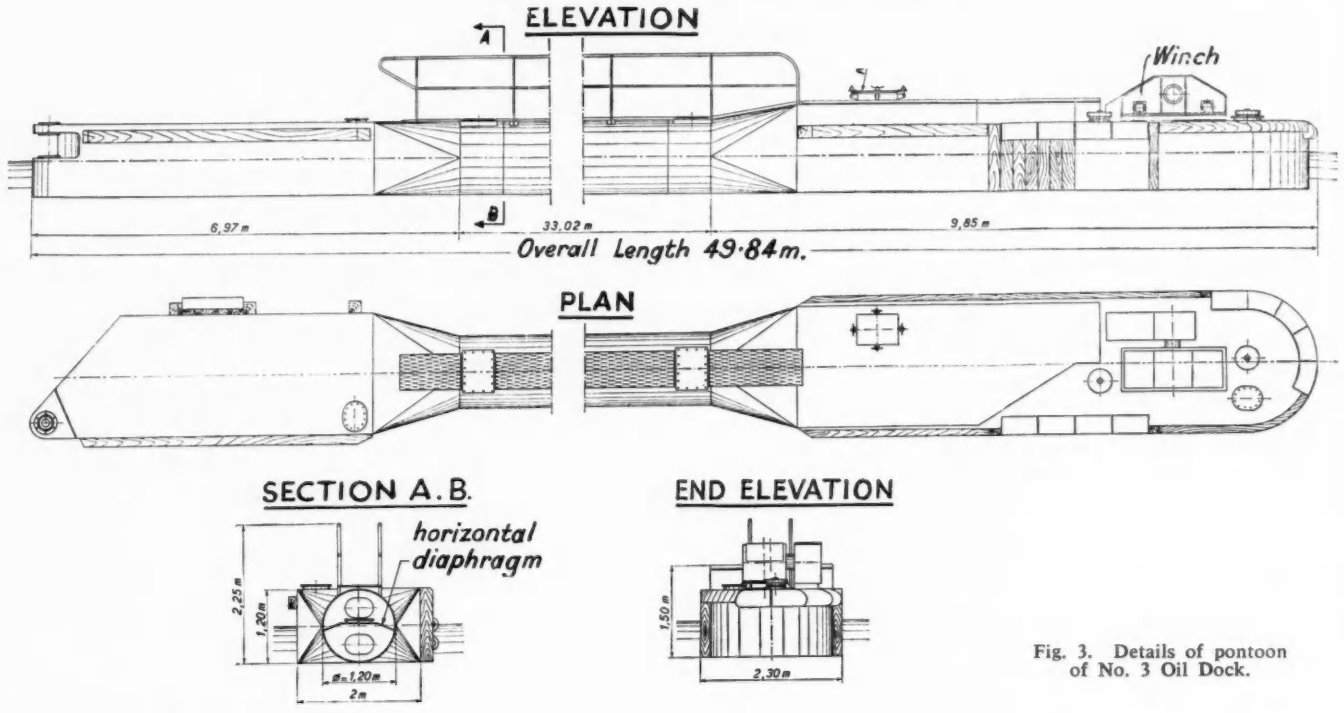


Fig. 3. Details of pontoon of No. 3 Oil Dock.

a winch mounted on the end of the leading pontoon. The design submitted by the firm of Etablissements Duchesne & Bossière was considered to provide the most suitable solution and was adopted by the Compagnie Industrielle Maritime. The design embodied two significant new features. In the first place, the gate was separated into two halves, each consisting of three pontoons, which folded back on either side of the dock entrance. This arrangement made for quicker opening and closing. Secondly, two submerged chains, instead of only one as envisaged in the original scheme, were provided: one of these chains connected the outer angles of the zig-zag line formed by the pontoons when in the "-closed" position, while the other connected the inner angles. By this means a more positive control over the movements of the pontoons was obtained, which was especially important under conditions of strong wind or tidal current.

The two entrance pierheads of No. 3 oil dock are 193 m. apart. They form the supports for the end articulations of the gate, which are capable of vertical sliding movement so as to permit the pontoons to rise and fall with the water level. To each pierhead is attached a set of three pontoons connected to one another by articulated joints. In the "open" position each set of pontoons is folded back and rests against a steel dolphin positioned at a distance of about 50 m. from each pierhead. In the "closed" position—which is obtained by extending the pontoons concertina-wise across the dock entrance—the ends of the two leading pontoons meet each other midway between the two pierheads. The movements of the pontoons are produced by means of five electric winches (three of which act upon one of the chains, and two upon the other) equipped with wheels having pockets which engage the links of the chains. The ends of the outer chain are attached to the dolphins while those of the inner chain are attached to the pierheads. When the gate is open, the chains lie on the bottom; when it is closed, they are stretched fairly taut between the winches and points of attachment. Opening or closing the gate takes five minutes to accomplish and is a fully automatic operation, being effected by push-button control from any one of four control points installed in strategic positions around the dock.

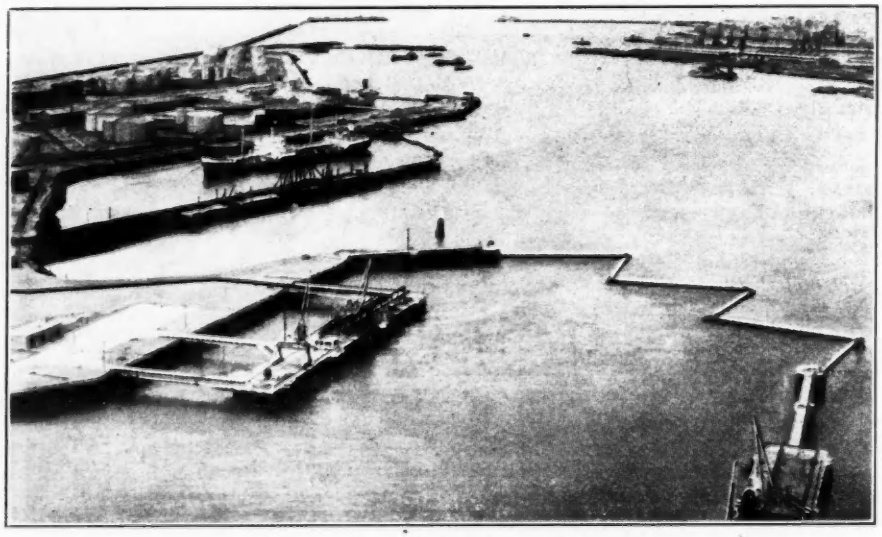


Fig. 4. Aerial view of gate of No. 3 Oil Dock.

From the structural point of view the gate in the "closed" position, together with the chains, forms a horizontal "lattice girder" of considerable rigidity, the chains being the chords and the pontoons the web members. The latter are thus subjected to axial forces only. Thanks to the arrangements adopted, the designers were able to comply with the following four important requirements:

1. the gate has to form a barrier across an opening of 193 m. without any inter-

mediate supports in the form of anchoring devices and the like;

2. opening and closing the gate by "unfolding" and "folding" the pontoons must be effected automatically;

3. it must be possible to operate the gate in all weathers and under all tidal conditions;

4. the gate must remain located within closely defined limits, without any possibility of "wandering", so as not to endanger the tankers moored in close proximity to it.

The pontoons, which are about 50 m. long, have a draught of 0.60 m. and a minimum freeboard of 0.60 m. The steel hull is of welded construction and consists of a tubular central portion (1.20 m. diameter) about 35 m. in length, terminating at each end in an enlarged portion of rectangular section 8 m. in length, 2 m. in width and 1.50 m. in height. The tubular part of the pontoon is provided with a longitudinal horizontal diaphragm and with vertical bulkheads at intervals of 2 m. Some of the lower compartments are ballasted to ensure stability.

The winches are mounted on the rectangular end portions of the pontoons. The driving motors and other electrical equipment are accommodated inside. Each winch has two operating speeds, viz., a high speed for carrying out the movements generally, and a low speed for obtaining precision control in the final stage of the opening or closing movement. In addition, resilient fenders are provided for absorbing the remaining kinetic energy.

The articulated connections between the various pontoons are of resilient construction so as to absorb any impact blows that may arise when the pontoons heave up and down in rough water. In addition, the articulations are flexible in the sense that they permit a certain amount of independent pitching movement of the pontoons. The attachment of each end pontoon to its pierhead embodies several degrees of freedom: rotation of approximately 120° about a vertical axis for the actual opening and closing movements; vertical movement over a height of approximately 8 m. to enable the pontoons to rise and fall with the tide; and a certain amount of rotation about two mutually perpendicular horizontal axes so as to permit pitching and rolling movements.

Hydrographic Surveys of Ghana Coast

Review of Work carried out in connection with Tema and Accra Harbours

By G. C. POWER

The rapid economic development of Ghana during the post-war years made it imperative that facilities along the seaboard for handling an ever-growing amount of shipping should be greatly improved and, for this purpose, in order to decide upon the most suitable site for a new port, considerable hydrographic work had to be carried out in the area. Most of the work was entrusted to the Contract Survey Department of Kelvin and Hughes (Marine) Ltd., and the following is a brief account covering four major surveys carried out in Ghana by this company.

The first and undoubtedly most important post-war survey was that which determined the choice of the site for Tema Harbour, situated 21 miles east of Accra, in Ghana, and now the largest artificial port in Africa. This survey was carried out in 1950, on behalf of Sir William Halcrow & Partners, Consulting Engineers for the Gold Coast Government. The sounding survey had to furnish details of two sites, one of which embraced a five mile stretch of coastline at Tema to approximately one mile offshore, and the other an area of similar dimensions twenty miles away at Teshi. It had to be based upon a precise shore framework and, therefore, the land survey was of the utmost importance as any error at that stage would have affected the whole of the subsequent work.

The first requirement was to create such a framework and with this in view a closed traverse of the coastline at Tema was carried out. The Tema shore control or framework having been completed and the positions of objects (either natural or artificially erected) established to the order of accuracy required, the survey team then ran a sextant traverse along the coastline and set off transit lines by sextant angles at required intervals along the traverse legs.

Transits were pegged out in order that targets could be erected as front and back marks for each line and the coxswain of the survey vessel then needed only to keep each two targets in line and the boat could be easily guided down the desired track. In actual practice, only two targets were used, as two men left on shore moved the targets along as the transits were run off. A sextant traverse was sufficiently accurate for this work and the transit marks were only a guide for controlling the sounding lines; the vessel's position was fixed on the main co-ordinated shore control stations.

Due to continuous heavy surf it was necessary to hire a canoe and crew from Tema village to ferry the team to and from the beach when manning the survey vessel, which had to be moored offshore. The traditional skill displayed by the natives in negotiating large breakers was a source of admiration to the survey team, but the tremendous force of the inrace often caused momentary loss of control even among the most experienced boatmen and upsets were not infrequent. The surf made it impossible to use normal methods while taking soundings close inshore, and necessitated levelling seaward, by pole, staff and level to 3-ft. below the low water mark. High winds between force 5 and 6 caused heavy swells and often made this work impossible, thus causing delays.

Several weeks were spent chaining the legs of the traverse and observing the angles by theodolite before the shore control was established to permit sounding operations afloat. For this operation, equipment which included a Kelvin Hughes Type MS.21A Echo Sounding Recorder, specially designed for hydrographic work, together with batteries, a 30 Kc Outboard Oscillator and a Tachometer was installed in the survey vessel. The echo sounder was capable of giving an accuracy unsurpassed by any other method and created a permanent record of all soundings recorded on dry paper, with fix marks automatically drawn simultaneously to each fix taken by the surveyor. By drawing the Tide Datum line on this record it was possible to read off reduced soundings and so avoid a mental correction to each individual sounding before entering it on the plotting sheet. An additional task during these sounding operations was to ascertain the nature of the sea bed from samples obtained by using a grab at frequent intervals.

Labour discussions played a very important part in the success of the survey operations and difficulties arose from time to time. Local labour had to be hired for the construction and setting up of shore marker beacons, etc., and for this purpose palavers had to be held with local African chiefs. Considerable tact had to be employed as local religious customs prevented work on land on certain specified days, and at sea other regulations had to be strictly complied with a avoid friction with various tribal authorities concerned. This led to a considerable amount of bargaining and discussion but, eventually, all problems were settled to the satisfaction of those concerned.

The transit runs were spaced at 200-ft. intervals and at right

angles to the depth contours along the coastline to be surveyed at Tema. In spite of delays due to weather these transits were run and all soundings completed in the area during a period of twelve days. The necessary framework to connect the Tema and Teshi areas geodetically and establish permanent stations (i.e. fixed beacons or natural landmarks) within the triangulation to which soundings and further land surveys could be related, formed the next stage of the operation.

Aerial view of Tema Harbour

Work then began on completing the shore framework for the site to be surveyed at Teshi, and complications during this work illustrated the type of difficulties often encountered by hydrographic surveyors. The Teshi site presented a difficult problem because for about ¾ of a mile the area proved impassable due to a large number of houses huddled together with very narrow passages between them. These buildings extended right up to the cliff top and beneath, on the seaward side, irregular rocks created a barrier which prevented the team from going below. Exceptional heat experienced on this location caused abnormal refraction and delayed theodolite work. The heat and humidity also made conditions more difficult for the survey team which attempted to complete the survey to a tight schedule. However, work progressed at a much faster pace, mostly due to the African labour now being experienced in routine tasks. At Tema the traverses in an area one third bigger had taken five weeks—the traverses at Teshi were completed in just over one week.

All the traverses were orientated to colony bearing which is the meridian of 1′ 00′ 00″ West longitude, the applied convergence being to true North at Tema as determined by star azimuths. This meant that when the colonial survey unit extended their network to this area, they had only to tie in to any one station and apply a fixed constant to the local co-ordinates to obtain colony values for all stations and to avoid re-computing the whole of the local network which would have been the case had a local orientation been used.

When the Teshi transits were sounded, the fathom contour line on the Admiralty Chart was found to be much further seaward than the available data indicated, and this added to the time required for sounding each transit line. However, before this sounding survey could be completed disaster overtook the team. The survey vessel with all the sounding equipment was lost in a gale which tore the boat from moorings and capsized her. Fortunately, at this stage, the data already established by the Teshi sounding survey had indicated the unsuitability of the site for port development, due to the existing depth contours. Additional information required to complete a final overall evaluation of the site was provided by sounding the remainder of the seven fathoms contour line by means of a lead line operated from a canoe.

All the topographical work had been plotted on the sites, and all the soundings to ensure that the entire areas had been covered. It only remained to make a final check on echo records and tidal data before leaving for the U.K. where the final tracings were prepared.

The Tema survey provided the information which enabled the consultants to approve the site and plan for a new port. This decision immediately brought in its wake an associated set of problems, the most important being that concerned with the enormous amount of building material which had to be shipped into Ghana. Accra was decided upon as a port for supplies, due to its location near Tema, facilitating the construction of a railway line between the two centres but the handling facilities for landing bulk cargoes had always been and still were restricted at the former port for the following reasons. Due to shallow water, ships had always anchored roughly a mile off Accra, whilst their cargoes were discharged into surf boats which slowly carried every type of goods ashore through the heavy surf; because of this an investigation into the possibility of improving the harbour facilities at Accra had to be carried out. Kelvin and Hughes (Marine) Ltd., were, therefore, asked in 1951 by Rendel, Palmer and Tritton, consultants appointed by the government for the Accra scheme, to carry out a sounding survey of Accra Harbour (Fig. 1). Local climatic conditions and topography hindered operations. A close

Sweeping Survey in progress in Accra Harbour

traverse which had to be run to position the westerly fixing point required eleven points due to a thick palm forest located between the ordnance trig station and the foreshore. Bad visibility was encountered and, to make operations even more difficult, due to the time of year (August), working hours were limited whilst sounding the transits due to the sun being, for a great part of the daylight hours, directly behind the shore marks. This can be

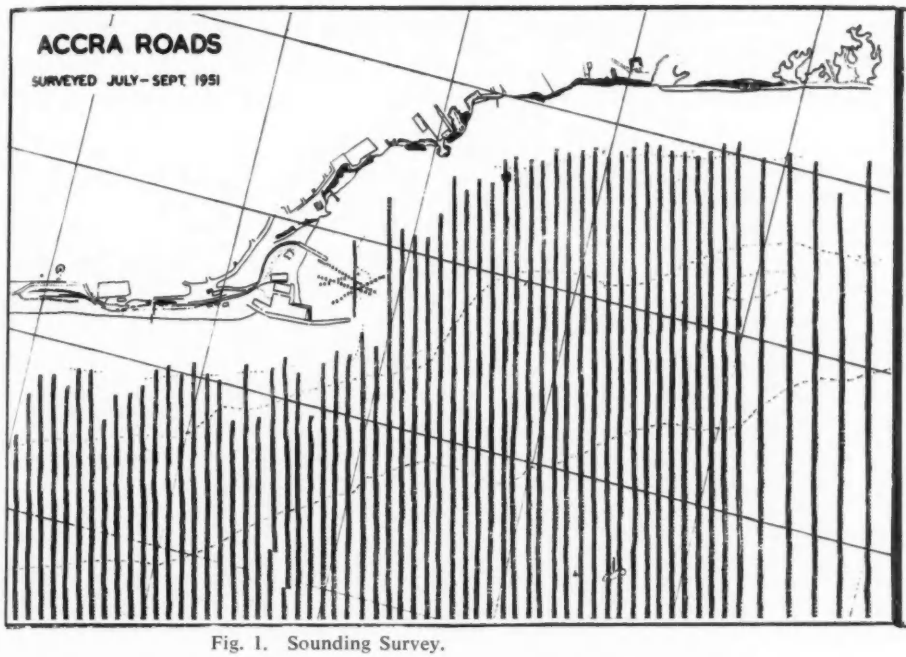


Fig. 1. Sounding Survey.

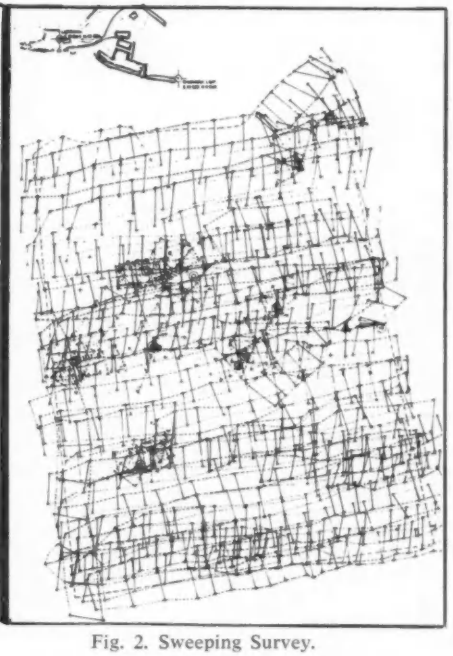


Fig. 2. Sweeping Survey.

appreciated fully when it is realised that the runs began two miles offshore. However, this contract was completed in under 6 weeks.

The next requirement was for a sweeping survey (Fig. 2) to be carried out off Accra to ensure that no obstructions existed on the sea bed which might constitute a danger to shipping using the offshore anchorage. During the often difficult conditions, due to ships riding light and rolling heavily whilst slings were operated to offload cargoes on to small boats rising and falling on to the swell, hundreds of tons of equipment and materials had ended up on the sea bottom. The natural result of this state of affairs over the years was to cause wariness on the part of the ships' masters and make them alive to the possibility of fouling their ships' anchors on various obstructions which they considered must exist. The writer can thoroughly appreciate this viewpoint, as he can remember often rolling about for weeks on end, roughly a mile of Accra, and watching several of the hair raising incidents which frequently occurred. The result of this caution which all ships' masters displayed was that ships tended to anchor further and further offshore, thus creating an overgrowing distance for the surf boats and their paddle crews to ply between ship and jetty. Something had to be done to persuade ships' masters to anchor closer inshore, and for this purpose the Contract Survey Department of Kelvin and Hughes (Marine) Limited was commissioned to carry out a sweeping survey of the offshore anchorage.

For this operation two launches were used, one being equipped with a Kelvin Hughes Echo Sounder and both with sounding wire booms. Difficulties were experienced at first with the type of wire used with the sweep, due to kinks forming whilst paying out. These were caused by the surge of the launches on the heavy swell. The wire also occasionally broke under the heavy strain imposed, but this trouble was rectified by using a heavier sweep wire. The weights and wires comprising the sweep were suspended between the two vessels to clear the bottom at 2 to 4 feet. The area designated for survey was swept to within 5-ft. of the bottom, allowing a 50% overlap, which meant, in effect, that the area was swept twice, and the only obstructions protruding above the level were two wrecks. All the obstructions marked obstruction or foul ground on the Admiralty chart, were then swept by dragging on the bottom to see if these existed at all so those that did not could be removed from the charts. This particular survey was completed to the satisfaction of the Marine Superintendent in Takoradi in 6 weeks.

Time passed and seven years later in 1958, work on the new Port of Tema had progressed to the stage when the authorities concerned had begun to think about ships entering the new harbour, and, as always, the first requirement was for a detailed navigational chart to be used by such vessels. The new area to be surveyed in detail extended nearly one mile to seaward of the large-scale survey previously carried out in the vicinity by Kelvin Hughes and a sweeping survey of harbour approaches was also required.

Due to the length of runs required when sounding the transits, 25-ft. marker beacons were erected on shore by the team, but even these were sometimes difficult to see. The usual difficulties cropped up and time was lost whilst numerous fish traps were cleared out of the way to enable the survey vessel to get to work. The rough water still made things difficult for the hydrographic surveyors, but in spite of one particularly narrow escape when the startled team suddenly found themselves broadside on to a 12-ft. breaker, everything went off well and the work was completed under the estimated time required.

The sweeping survey carried out in the approaches to the harbour located a 12-ft. pinnacle of rock almost centrally placed between the two breakwaters forming the harbour mouth. This discovery alone undoubtedly proved that the sweeping survey was really necessary and underlined the importance of this type of work. The obstruction in question was later destroyed by explosives.

Proposed Improvements at the Port of Amsterdam

To cope with the increase in traffic at the port of Amsterdam, additional cargo facilities in the old West port area are to be provided at a cost of nine million guilders. General cargo piers and sheds in the north part of the former Log basin (Houthaven) are to be constructed and the water alongside the new piers will be dredged to a depth of 22-ft. Eight cranes will be moved from the Coenhaven area to the new facilities and the Coenhaven equipment will be replaced with new large cranes with a reach of 131-ft.

The German Pallet Pool

Inauguration of Simple and Economic System

In conjunction with the Milan Fair in April last, the International Container Bureau, besides organising an exhibition of containers, arranged for a series of technical papers to be presented, dealing with various aspects of cargo handling by containers and pallets. Among these was a paper by Dr. E. Hay (head of the Traffic Division of the Federal Association of German Industries) on the inauguration of the German Pallet Pool.

The first pallet pool in Europe was launched several years ago by the Swiss Federal Railways. A quickly proved benefit of the scheme was a much better use of cubic space. Three times the former quantity of goods can now be stored in their depots. Sweden, France and Holland followed with similar schemes and recently it was decided to launch a European pallet pool which, it is hoped, will pave the way for an international pool.

The pallet sizes adopted for most of these national schemes, including the German, is 32-in. x 48-in., which is, in fact, one of the sizes standardised internationally by the International Organisation for Standardisation (ISO). This popular size has also been adopted by the Economic Commission for Europe for application to the European pallet pool, the organisation of which has been entrusted to the International Union of Railways. The new *Europe* standard pallet railway wagon gives very good loading for this particular size.

The following is an extract of the paper in question.

Dr. Hay began by stating that the continuous development of motorisation has completely changed the structure of transport in the various European countries, resulting in increased research into the question of equitable distribution between the various forms of transport in order to make the best of their several characteristics, and in the need for co-ordination. It was this latter aspect with which he was going to deal.

The " supply " side of transport has considerably altered, as has the " demand "—many traffics having completely disappeared after the war, while others have been created. Speed is the order of the day, and the criterion now is " What is the quickest way of transporting my products from the machine producing them to their ultimate destination? " A natural consequence is an endeavour to group products into unit loads in order to cut out all intermediate handling of individual packages.

A newspaper recently likened a pallet to the tray on which a waiter can simultaneously carry all his clients' varying orders. Pallets, of course, differ widely in different countries, some being interchangeable between different forms of transport and some not. Many firms made their own pallets to meet their own particular requirements, and so a variety of national and international " parks " came into being; but the economic disadvantage of " return empties " remained unsolved, so that each owner had to carry an enormous stock of pallets to ensure a regular cycle of availability. It was for this reason that the idea of standardisation of dimensions and construction was born.

After protracted discussion between various international bodies, the dimensions of the Standard Pallet for Europe was decided as 800 x 1200 mm. (32-in. x 48-in.), after the German Federal Republic had offered to discontinue certain types in order to facilitate uniformity. This country is thus one of the first founders of the Pallet Pool.

The German Pallet Pool came into operation on 1 January 1960, and it is a system both simple and economic, with 3 basic requirements. Pallets must be (1) of uniform quality and dimensions, (2) capable of use within the country as well as internationally, and (3) interchangeable between the various forms of transport.

The following rules apply to pallets for admission to the Pool:—

(1) **Definition:** An interchangeable pallet is one that becomes the property of the person accepting it in exchange for one of his own of the same type; it can be sent by any type of road or rail transports. (It is hoped to extend its use later to air and inland waterway transport.)

(2) **Dimensions:** Flat, and box-type pallets of 800 x 1,200 mm., conforming to certain technical standards of construction. Another type of box-pallet is under consideration, and the old 1,000 x 1,200 mm. box-pallet is also provisionally admitted as a transitional measure.

(3) **Marking:** All pallets have a **special mark** and this, pending decision on a single mark acceptable throughout Europe, is the German Railways' own mark (D.B.).

(4) **Stocking:** Pallets are stocked in the producers' warehouse and also, on payment of small charge, on railway premises.

(5) **Handling:** Differs very slightly according to the form of transport.

(6) **Participation:** Anyone wishing to enter the Pool has merely to acquire sufficient pallets for his needs, and accept the general rules. He should advise the transporter or forwarder in advance, to ensure that an equivalent number of " empties " are held at his disposal.

(7) **Small packages:** In this traffic, one loaded pallet is exchangeable against one empty and vice-versa. Where complete truckloads are involved, exchange is on the basis of individual agreements between shipper and transporter, and special rules are being devised.

(8) **Handling and replacement:** For the account of the person accepting the pallet.

(9) **Guarantee of conformity to standard:** In order to comply with the standards laid down by the German Society for the Study of Combined Transport, manufacturers of pallets have formed themselves into a " Pallet Community ", and guarantee their products, on which they are allowed to stamp the special mark.

No administrative machinery is required for this simple system beyond a small office for the " Community " and a railway check-point. Anyone can join provided he accepts the rules and holds sufficient pallets to meet his needs; giving an empty pallet in exchange for a loaded one.

It is hoped that everyone will eventually join the Pool, though there will always be certain traffics which require specialised pallets.

No duty is imposed on the pallets coming into or going out of Germany; the German Customs merely take the number of pallets and periodically draw up a " balance " as between the various countries concerned. Germany agrees with this procedure and considers that duty should only be imposed on new pallets imported for sale.

The Pool has been favourably received in neighbouring countries, though it is realised that it cannot become general overnight. However, it is true to say that its maximum economic advantages will only become apparent when the Pool covers the maximum number of countries.

Proposed New Port at Ashdod

According to recent press reports, the World Bank has granted a loan of $27,500,000 for the construction of a deep-sea port at Ashdod, some 20 miles south of Tel-Aviv.

Repayment of the loan will be over a period of 25 years, and the new port will serve the southern sector of Israel where a new city and industrial centre are already being built at Ashdod, on the site of a former Philistine coastal town. Loans are also being negotiated between Israel and the World Bank to finance the expansion programme of Israel's potash works on the Dead Sea.

Granary Extension at Port of Glasgow

Increased Storage and Intake Capacity at Meadowside

THE extension to Meadowside Granary, built by the Trustees of the Clyde Navigation at a cost of £4 million, was officially opened on 8th July last. The largest single item of capital expenditure ever undertaken by the Trust, this project marks another step in a substantial programme of improvement and extension of facilities at the Port of Glasgow.

The Trustees' original granary which was opened in 1914 afforded storage capacity for 31,000 tons of grain and an extension constructed in 1938 increased this figure to 46,000 tons.

The new granary extension with a capacity of 50,000 tons more than doubles the previous storage capacity. Six new travelling quayside suction elevators have been provided and these with the existing appliances will enable an average intake of 1,000 tons per hour to be achieved.

General Description of Building

Although a single structure, the new granary building consists of three main parts, these being the two working houses at the extremities and the centre silo section containing the storage bins. The overall length is 387-ft. of which the silo section occupies 315-ft. The two nine-storey working houses are 36-ft. by 97-ft. by 187-ft. high and house the main items of plant. Access to each of the working houses is provided by means of a staircase and electrically operated lift, a machinery hoist also being available for plant maintenance and replacement. The ground, first, second and eighth floors are continuous throughout the full length of the building.

The main section of the building between the working houses is 90-ft. wide and 159-ft. high, comprising 114 bins each of 400 tons capacity 15-ft. square by 97-ft. deep and 24 bins each of 200 tons capacity 15-ft. by 7-ft. 6-in. and of the same depth. The smaller bins are situated twelve at each end adjacent to the working houses. The bins all rise from the third floor to the eighth floor and provide storage space for 50,400 tons of grain.

The workshops, offices, messing facilities and main control room are situated in an amenities block approximately 135-ft. long by 12-ft. wide cantilevered from the first and second floors to the south of the silo section of the building.

The foundation of the building consists of a reinforced concrete raft 4-ft. thick resting upon boulder clay. The framework of the building is constructed in reinforced concrete throughout with a straightforward design of columns, beams and floor slabs. The bin walls are also constructed in reinforced concrete. The walls of the working houses are of cavity construction with either facing bricks or precast granite faced slabs on the exterior faces. The external bin walls are covered with facing bricks to give the building a uniform appearance and also to provide additional protection for the reinforcement in the bin walls.

An interesting feature of the construction is the formation of the 138 storage bins which are erected in six separate groups or sections using the system of sliding formwork. The timber sliding shutters for each section were set up to the plan shape of the group of bin walls, a working deck fixed to the top of the shutters and this assembly jacked up vertically on 1-in. diameter high tensile steel rods by means of hydraulic jacks with simultaneous fixing of the steel reinforcement and feeding into the shutters of the wet concrete from the working deck as the shutters were raised by the jacks, the timing of the whole process being such that the concrete had set sufficiently to be self supporting by the time it emerged from the lower end of the 4-ft. deep shutters.

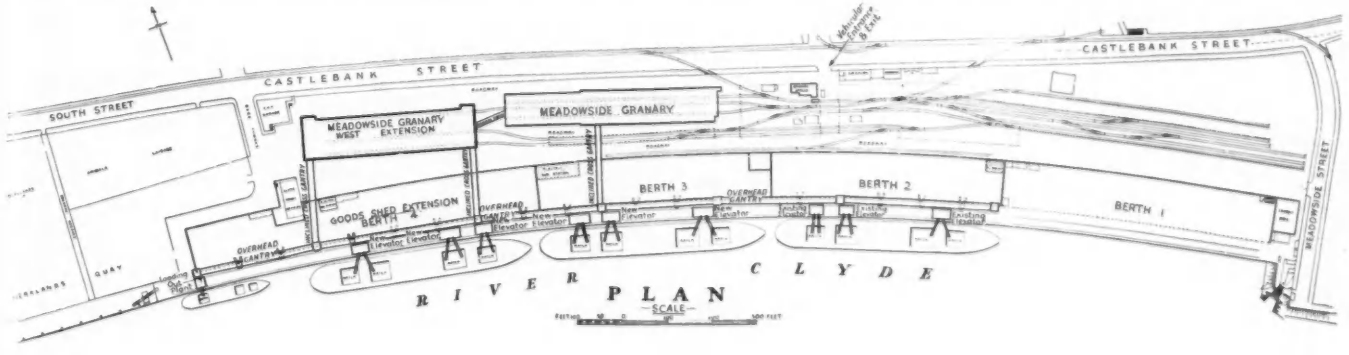
Once a slide had commenced the work had to proceed continuously on a 24 hours a day basis until it was completed; the average time taken to slide each section was seven days. No two adjoining sections were slid successively and the time between the completion of one section and start of the next was about 3½ weeks, the whole of the bin construction being completed by this method in less than 6 months as against about 18 months if the normal "hand over hand" shuttering method had been adopted.

To form the concrete frame and walls of the building 25,000 tons of crushed whinstone, 16,000 tons of sand, 7,000 tons of cement and 2,400 tons of steel reinforcing rods were used and to provide the cladding about one million bricks, 12,000 facing slabs and 25,000 square feet of glazing were required.

Intake Plant

The existing rail track for the travelling quayside pneumatic elevators has been extended 885-ft. westwards along the quay to cover an additional 115-ft. of quay in Berth 3 and 770-ft. of quay in Berth 4. The extended rail track is carried on a continuous reinforced concrete beam supported on bored piles of reinforced concrete.

Six additional pneumatic elevators have been provided to run on this track, each elevator being fitted with two suction nozzles, the total rate of discharge of grain from vessels using these machines being 1,200 tons per hour. The new elevators feed the grain on to the conveyors in the new overhead gantry. The three existing pneumatic elevators at Berths 2 and 3 will be adapted to



feed on to the overhead quayside conveyors. These new plants, with the three existing plants, have a combined intake capacity of 1,550 tons per hour.

Four conveyor bands, each capable of dealing with 400 tons of grain per hour, are housed in high level gantries which have been erected longitudinally along Meadowside Quay at Berths 2, 3 and 4. The gantries are of steel frame construction, the exterior cladding being formed of galvanised steel plating. Trestle supports carry the quayside gantry approximately 36-ft. above the quay breast, these supports being seated on reinforced concrete foundations supported on R.C. bored piles. The total length of the quayside gantry along Berths 2, 3 and 4, Meadowside, is approximately 1,800-ft., this length being sufficient to serve three vessels of normal size with bulk grain cargoes discharging simultaneously.

The quay has a slight curve of one mile radius and the conveyors which must run in straight lines are arranged in runs between seven junction towers each of which alters the course of the gantry. At three of the junction towers the grain can be diverted to transverse inclined gantries, one delivering to the west and one to the east working house of the new granary and one delivering to the old granary building.

The four lines of intake conveyors in the quayside gantry carry grain in an east to west direction, except at the extreme west tower where there are two conveyors only running in a west to east direction and delivering grain via the inclined gantry to the west working house of the new building. Similarly there are four grain intake conveyors in each of the transverse inclined gantries serving the new granary.

The whole intake of grain conveyed along the quayside gantry can be delivered to either of the two working houses of the new granary. Two streams of grain from the quayside gantry can be delivered to the old granary by two transverse inclined conveyors. The conveyor belts are 36-in. wide with a speed of 750-ft. per min. and are each designed for a capacity of 400 tons per hour. Each line of conveyors is able to deal with the grain discharged by two pneumatic plants. Considerable variation is thus possible in the distribution of the intake of grain.

Additional weighing facilities are to be introduced in the floor section of the existing granary building on the line of the new overhead gantry, yet to be erected, from the quayside gantry and, once this has been carried out, the overhead gantry constructed and the three existing pneumatic elevators converted as above-mentioned, the existing conveyors in the grain band subway at Berths 2 and 3 will be put out of commission.

Reception and Distribution

Each of the eight inclined conveyors by which grain can enter the new granary delivers to a 30-ton garner. The grain is then discharged into an automatic bulk weigher which weighs 5 tons at a time. Depending upon the rate of intake of grain, the weigher tips at intervals of approximately ¾ of a minute into a hopper for delivery to one of the main elevators.

At the elevator head the grain is transferred to a distribution conveyor for delivery to storage bins.

For receiving and distributing, there are in each working house four garners, four automatic weighers and four bucket type elevators each of 500 tons per hour capacity.

For distribution to storage bins there are eight distribution conveyors on the eighth floor located lengthwise between the west and east working houses above the bins. Four distribution conveyors deliver grain in an east to west direction fed from the east end elevator heads and similarly four in a west to east direction fed from the west end elevator heads.

Facilities are provided for "turning over" the grain from any bin to any other bin and also for transferring grain from the new to the old granaries. This is effected by feeding grain through spouts on to collection conveyors running along the first floor of the granary.

The collection conveyors, four in number, are reversible and deliver on to a cross conveyor in the west working house. From this cross conveyor the grain is routed via a loading-out elevator and weigher, to the boot of any of the main elevators in the west working house and so "turned over" into any other bin or, if grain is to be transferred to the old granary, it is delivered to two secondary elevators of 500 tons capacity which discharge to the intake garners. It then passes through one of the bulk weighers and is re-elevated by one of the two middle main elevators in the east working house to a conveyor leading to the old granary at the conveyor gallery floor above the bins.

Loading Out Grain to Road, Rail or Ship

In Bulk. Grain is loaded out in bulk to road vehicles and railway wagons direct from the main storage bins. Road vehicles have access to the underside of the granary through 21 bays passing tranversely under the building. Three lines of rail tracks run longitudinally under the building, each line serving two rows of bins.

Grain can be loaded out from twelve bins at a time by means of a battery of 24 portable 10-cwt. weighers arranged to operate in pairs on the second floor. Each pair of weighers feeds grain through openings into hoppers terminating in short telescopic spouts above the open ground floor. The flow of grain to road vehicles can be controlled by the driver by means of a hand-operated control valve.

In Sacks. There are 18 portable sack weighers on the second floor which are used for loading grain into sacks direct from the main storage bin outlets. The sacks are delivered to road vehicles or railway wagons through chutes in the floor.

To Coasters. Grain to be loaded out to coasters is delivered by collection conveyors on the first floor to the cross conveyors in the west working house. It is then routed to a 2-ton automatic weigher via a 200-tons capacity bucket elevator.

Grain to be loaded out in bulk is delivered to a conveyor of 200 tons per hour capacity housed in the west inclined gantry and running down to the west tower on the quayside gantry. Here it is transferred to a conveyor of similar capacity in the main quay gantry which in turn feeds a portable conveyor delivering the grain into the hold of the coaster.

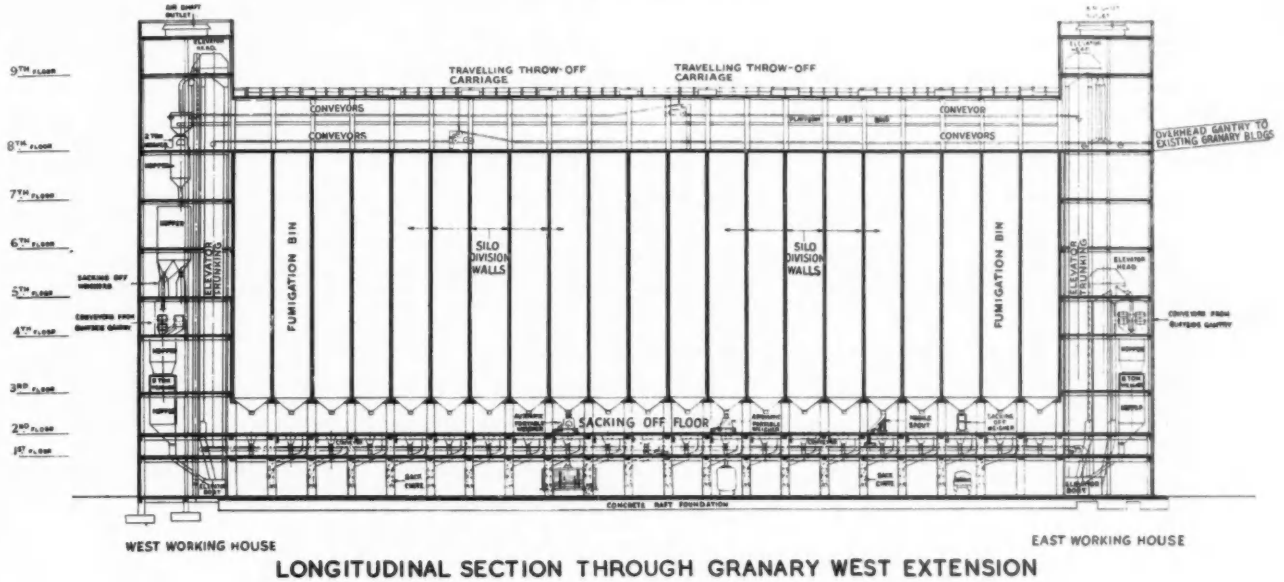
Grain loaded out in sacks follows the same route, but after leaving the bulk weigher the grain is sacked-off in portable sacking-off weighers. The sacks are then transferred by chute to the inclined loading out conveyor.

The inclined conveyor, the quayside gantry conveyor and the portable conveyor forming the loading out conveyor line are designed to work at 650-ft. per minute when handling bulk grain and 220-ft. per minute when handling sacks.

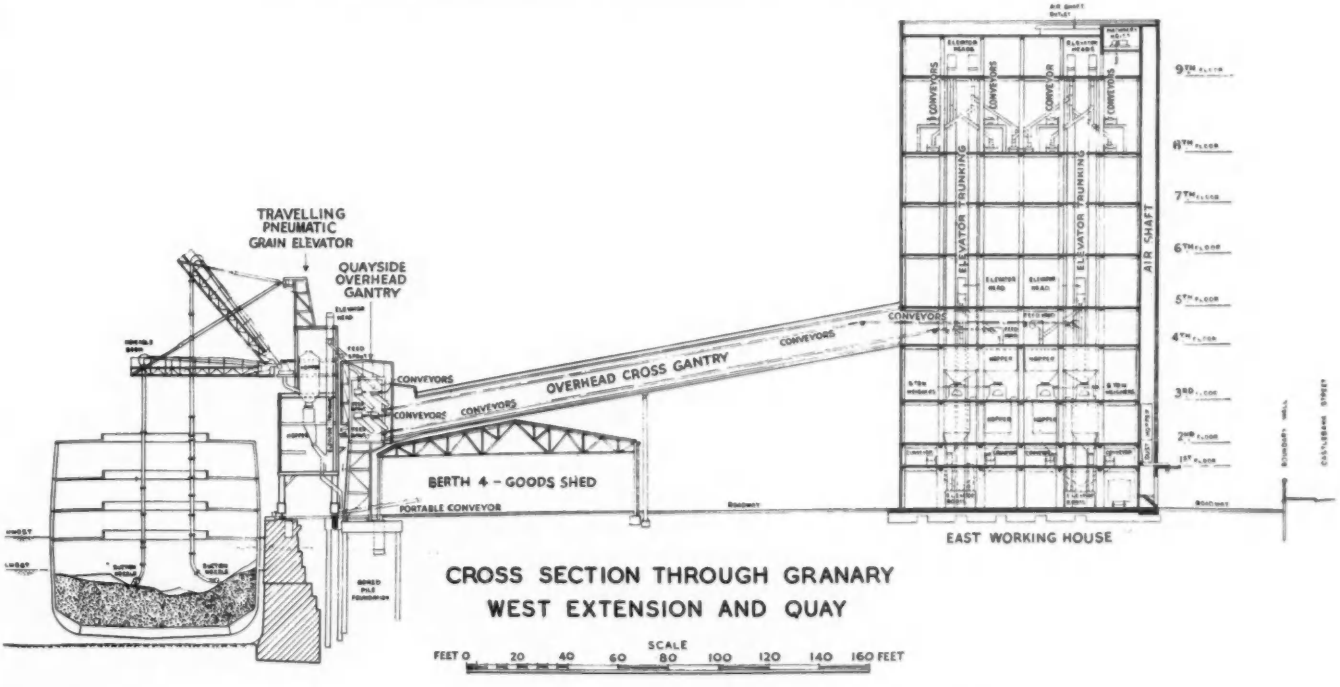
Fumigation and Temperature Recording

To allow pressure fumigation of infested grain, the six 400-ton bins at each end of the bin section have been made gas tight and two separate fumigation plants are installed serving these bins at each end of the main block. Methyl bromide gas, which is lethal to weevils or other insects infesting grain, is injected by means of a fan and system of piping. The gas is circulated through the bin for a period and then drawn off. After disinfestation the grain is transferred to one of the main storage bins.

Grain which is in such a condition that spontaneous heating may subsequently occur can be stored in any one of the forty-two bins which are fitted with temperature recording instruments so that the grain can be kept under observation and turned over if necessary. Provision has been made for the extension of this facility to all bins if required.



LONGITUDINAL SECTION THROUGH GRANARY WEST EXTENSION



CROSS SECTION THROUGH GRANARY WEST EXTENSION AND QUAY

Fire Protection

The whole of the building has been designed to give the maximum possible safety in the event of fire, each floor being capable of separation from the remainder of the building by the automatic closing of steel doors fitted with fusible links. The eighth floor or conveyor gallery is split into two separate sections by the introduction of a longitudinal brick firewall rising from floor to ceiling and running centrally along the complete length of the building. The ends of the conveyors running from the new into the existing building at this level are contained in their own fireproof compartment to guard against the spread of fire from one building to the other. Steel firedoors with fusible links are built into these firewalls to ensure that grain operators have a means of escape from any compartment and fire escape hatches are positioned in the roof over the conveyor gallery to give an alternative means of escape if required.

A 4-in. diameter dry rising main has been installed adjacent to the stair well in each working house fitted with 4-way inlets at the lower ends located outside the building and instantaneous connecting couplings in the stair well at each floor.

The building is protected by an automatic fire detection and alarm system incorporating over 335 detector heads. The detector system is connected direct to the control room in the granary and also to Glasgow Fire Station, where indicator panels will register the exact location of any outbreak of fire in the granary or gantries.

Dust Collection

Dust fans are situated throughout the building and are automatically brought into operation when their associated conveyors and elevators are started up.

Granary Extension at Glasgow—continued

Electrical Equipment

To meet the demand for electrical energy for all the new plant two 6.6 kV feeders from the South of Scotland Electricity Board, Glasgow Area Network, were installed in the main sub-station, each rated at 800 amperes, feeding a 6-panel sectionalised switchboard comprising Reyrolle C6T panels to supply the Meadowside Quay installation by separate feeders. The scheme is arranged so that three sub-stations located at Berths 2, 3 and 4 respectively are fed at 6.6 kV from the main switchboard and connected to each other by interconnectors. Reyrolle type C6T horizontal draw-out switchgear, rated at 250 MVA, is installed.

The sub-stations at Berths 3 and 4 respectively also feed two 1250 KVA air-cooled 6.6 kV transformers situated in the east and west working houses of the new granary.

Distribution. From the main sub-stations at Berths 2, 3 and 4 a 440 volt 3 phase and neutral supply is provided for distribution to all quay wall gantry electrical equipment. Low tension switchgear—Reyrolle air break horizontal class SA type, 440 volt, 3 phase, with a capacity rating of 31MVA—is used. The low tension distribution system is split into three sections as follows:

(1) The air break distribution boards in east and west working houses of the building feed a series of group starter boards which control the whole of the plant associated with the intake and turning over of grain in their sections of the building. They also provide the feed for the main lighting section and service switch fuse distribution board in each working house. The 440 volt, 3 phase and neutral supplies are also taken from main sub-stations at Berths 2, 3 and 4 respectively to switch fuse distribution boards in three of the gantry towers which feed motor group starters in the gantry towers to control the whole of the gantry electrical system.

(2) On the 1,800-ft. long quayside gantry a 3 phase overhead conductor system provides electrical energy for the quay wall travelling pneumatic elevators. The conductor bars are split into three sections and are fed from their nearest main switchboard in sub-stations at Berths 2, 3 and 4 respectively. The supply to each of these sections comprises two feeder units each of which is split into two feeders making a total of four cable feeds from each sub-station. The overhead conductors comprise three $2\frac{1}{2}$-in. x $2\frac{1}{2}$-in. x $\frac{5}{8}$-in. hard drawn copper tee bars.

(3) The six new pneumatic plants pick up their supply from the overhead trolley system by means of two collector arms. The collector gear feeds a switch fuse distribution board which in turn feeds all the electrical equipment necessary for the operation of the plant, including a 440/110 volt lighting transformer. The pick up of the three existing plants is similar to the above, but in this case, as the plant is D.C. operated, the feed is to 200 kW silicone rectifier equipment fed from the overhead trolley system.

Control. Each group starter board has an isolator switch and each individual starter has a set of H.R.C. fuses, triple pole solenoid overload protection and load isolator.

In normal operating conditions all conveyors and fan drives are controlled from a mimic control panel located in the main control room on the second floor of the new building. This panel comprises a factual mimic of the granary including the layout of storage bins, conveyors, weighers, fans, etc.

Integral with each of the conveyor lines are start/stop push buttons and two indicating lamps which, when lit, indicate the direction of flow. The controls on the mimic are on a 50 volt A.C. supply and arranged so that drives can only be started up in sequence. To signify that any drive is running audible alarms are provided. In the event of any drive being tripped, intertripping to the source of the feed will take place and so prevent spillage of grain. By means of selector switches or stop/start push buttons on the group starter boards the drives can be run out of sequence. Audible alarms can also be sounded from the starter boards. Emergency trip wires run the full length of all conveyors.

Cabling. The main feeder cables to the granary and gantry are P.I.L.C.S.W.A. & S. Distribution wiring is Butyl S.W.A.P.V.C. cable and small motor drives in P.V.C.S.W.A.P.V.C. The lighting installation is carried out in pyrotenax.

Indication Control

The amount of grain in each of the 138 storage bins is shown on the mimic control panel. Facilities are provided to reduce the quantities shown in the 138 bins so that at the end of each day the quantity of grain which has been taken out that day can be deducted, thus obtaining a true record of bin contents.

Facilities are also provided to give audible and visual alarm when a bin is fed to within three tips of being full and also to lock out the feeding weigher when the bin is full.

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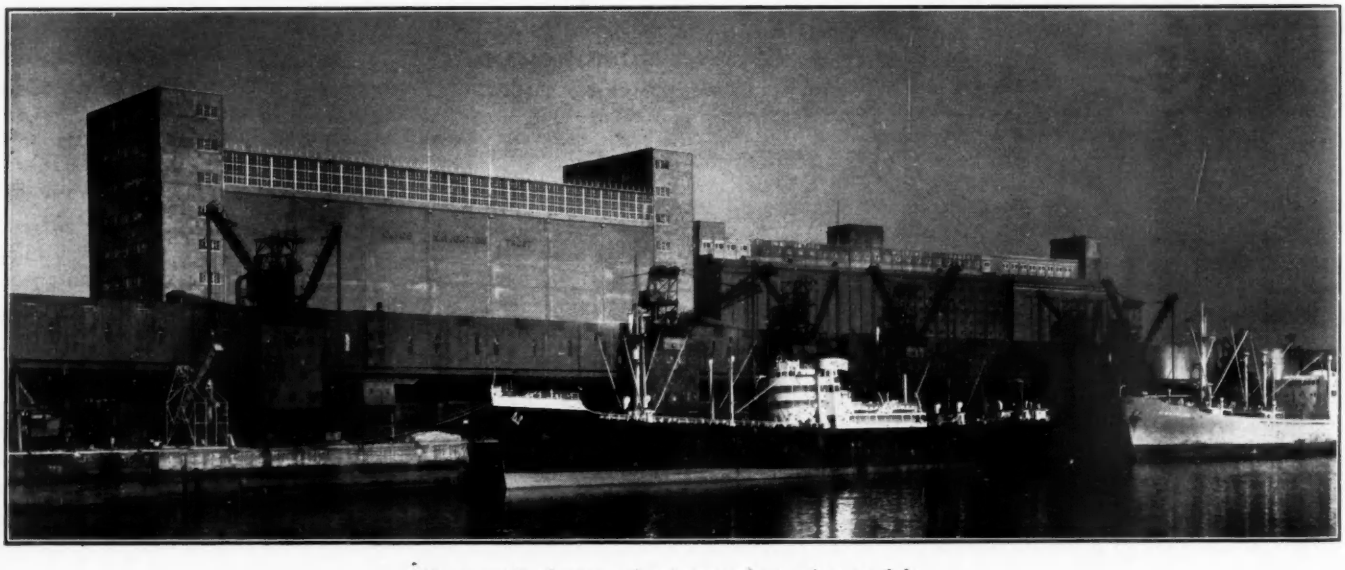


Meadowside Granary showing new extension on left.

Manufacturers' Announcements

New Short Range Electronic System for Hydrographic Surveys

The Mersey Docks and Harbours Board recently tested a new navigation system which could greatly assist them in their task of keeping the charts of the Mersey area up to date, accurately positioning the buoys which mark the channel along which all shipping entering the Port of Liverpool must pass.

One of the greatest problems involved in this work is that of locating the position of the vessel whilst soundings are being made and buoys being laid. Normally this positioning is carried out by observers on board the vessel, using sextants to take bearings of known points on the shore. However, in the bad weather which is a feature of this area, it is not always possible to see the shore so that fixing the ship's position is difficult and often impossible. It is to overcome this problem, that electronic engineers have, over the years, developed new equipment which can position the ship with great accuracy under all conditions of visibility. One of the latest of these is the system developed by the Decca Navigator Company, known as Hi-Fix, which utilises three shore radio stations transmitting special signals every second, which are received on the ship in a radio receiver fitted with counter type dials. The information displayed on these meters enables the position of the ship to be plotted on the chart, to an accuracy of a few feet.

For the purpose of the demonstration to the Mersey Docks and Harbours Board, three Stations were used; the master station was located at the port radar building and two slave stations were set up one at Formby Point and the other on Hilbre Island. Over the period of a week tests were carried out using a receiver installed on S.V. " Vigilant ".

On the " Vigilant " surveyors took fixes of the vessel's position using sextants and shore marks while readings were taken, at the same time, from the Hi-Fix equipment and the results obtained were compared to assess the accuracy of the system. The trial took the " Vigilant " along the buoyed channel and out into selected areas of Liverpool Bay. The results obtained were excellent and the small differences obtained over such a wide area between the traditional and radio methods of surveying, were good indication of the basic accuracy of each method.

The equipment used on board the vessel was small and compact and took only half an hour to install. Ashore, one station was installed in an existing building, one in a tent on Hilbre Island and the Formby station was installed in a light-weight fibre-glass caravan and towed to the site.

The Decca Navigator Company have also demonstrated this new survey equipment to the Swedish Hydrographic Department. The demonstrations were carried out in the Stockholm Archipelego, an area which although of great beauty is also a menace to shipping. Three Hi-Fix transmitting stations were built along the shore and the Hi-Fix receiver was carried on board the " Nils Stromcronor ", of the Royal Swedish Navy. At the same time observations were made by a team using theodolites.

Sweden already has a Decca Navigator chain as well as a small mobile chain which has been used for many years to assist the Swedish Hydrographers in the preparation of their charts. The Navigator System has a range of several hundreds of miles, but requires comparatively large installations, whilst Hi-Fix is small enough to be taken to a new site in a small rowing boat. Although its range is limited, with a nominal range of 20 to 40 miles the system is accurate to within a few metres over an area of thousands of square miles.

The receivers installed on the vessel incoporated highly sensitive indicators utilising dials similar to the mileage counters on a car speedometer. On the vessel also was a Frequency-Independent Display. This is a device which permits the frequency of the Hi-Fix transmissions to be changed without requiring different charts, and can express results in feet, yards or metres instead of ' electronic ' units.

Orders for the Hi-Fix equipment have already been received from Norway, Nigeria and Brazil, and interest in it has been shown in many other countries.

Granary Extension at Glasgow—continued

To provide for the quick change over from the filling of one bin to another during ship discharge radio telephones are provided in the main control room to give instructions to the operator on the distribution conveyor floor as to the flow of grain.

Miscellaneous

A 25-way automatic telephone system is installed throughout the granary and gantries. Radio telephones are located in the pneumatic plant, the main control room and the distribution floor. This gives the control man instant communication with all the feed and delivery points for the co-ordination of control. To facilitate delivery instructions between the despatch office and the granary foreman's office a Creed facsimile teletape transceiver is installed.

In the machinery and electrical installation 7 miles of rubber and canvas conveyor and elevator belting and 45 miles of electric cables were installed and in the quay wall elevators, the gantries and the grain handling machinery over 4,000 tons of steel were used. The total power installed amounts to 5,000 horse power.

The whole of the building and civil engineering work was carried out under the direction of Mr. Archibald Thomson, B.Sc., M.I.C.E., Engineer to the Trustees, assisted by Mr. R. Barclay Braithwaite, A.M.I.C.E., the Assistant Engineer and the whole of the mechanical and electrical work was carried out under the direction of Mr. Robert Shearer, M.I.M.E., Mechanical Engineer to the Trustees, assisted by Mr. James King, the Assistant Mechanical Engineer.

The new extension with its six additional discharging plants and increased storage capacity should make Glasgow one of the fastest grain-handling ports in the United Kingdom.

Corrugated Conveyor Belting

Conveyor belting which incorporates corrugated side walls to increase the capacity and gradient of a conveyor installation is now available from Numec Ltd., of New Whittington, Chesterfield.

This belting which can be used for many handling applications such as bulk grain, sacks, bales etc., is manufactured for Numec by the Dunlop Rubber Co. Ltd., in standard widths from 9-in. to 36-in. and with corrugated sides 2-in. and 3-in. high. It is constructed in rubber and canvas, the number of plies being governed by the load-carrying requirements of the specific application.

The corrugated sides form tough walls on the straight without tension at the ends and they increase the load-carrying capacity of the conveyor by 25 per cent in the case of the 2-in. side walls and by 50 per cent for the 3-in. compared with conventional belting. The side walls also allow an increase in the gradient of the conveyor, depending on the material being carried. The gradient can be further increased by the use of rubber flights moulded to the belt at right angles to the centre line of the conveyor.

This belting has been designed to run on straight idler rollers although it can be used, on existing troughed rollers. Where it is used on new installations it saves 70 per cent of the cost of supporting rollers, since one idler replaces three to five troughing rolls. The corrugated sides not only grip the load but also prevent belt sag between the supporting idlers.

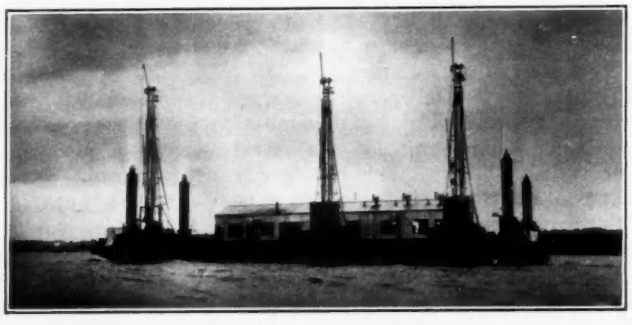
Manufacturers' Announcements—continued

Submarine Drilling Equipment

As a result of work carried out by the Joy Manufacturing Company, U.S.A., on several channel deepening and widening projects including the St. Lawrence Seaway, it is claimed that submarine drilling techniques have been considerably advanced. The method involves equipping a barge with a number of drills powered by air compressors, each driven by a sea water-cooled diesel engine. This equipment may be adapted for submarine blast hole drilling to operations of various sizes in channels, canals and rivers.

In operation, the barge is anchored over the working area and becomes a self-contained drilling plant with a limited amount of mobility. Two cables are run out diagonally from each end of the barge and anchored at a distance of up to 800-ft. By winching in cable at one end of the barge while paying out at the other, it can be manoeuvred in accordance with the drilling plan. Spuds, or piles, one at each corner of the barge are lowered by an air-operated hoist to ensure a stationary, level platform for drilling operations.

Assuming a three-drill barge is used, as in the accompanying illustration, with drills having an effective horizontal tracking distance of 80-ft., the operation proceeds as follows:— Holes spaced on 10-ft. centres permit the sinking of nine holes from



each barge position, allotting three holes to each drill. Once a tower has been positioned for drilling it is locked in place by a quick-acting clamp and a sandpipe is lowered until it rests on the sediment or rock to be worked. The sandpipe functions as a guide for the drill steel, prevents material from caving into the drilling, and also guides the charge into the hole for firing.

Drilling proceeds in the normal manner, using air pressure to blow the holes. The drill is then raised in the tower and a dynamite loading tube lowered by air hoist down the sandpipe to the bottom of the drilling. The bottom stick of dynamite contains a detonator with a lead wire to the barge deck, so that after the charge has been ejected from the loading tube and the tube withdrawn, the leads from all holes may be connected up. The sandpipe can then be raised and the drill tower moved to the next position where the process is repeated.

When all holes have been drilled and loaded, spuds are raised and the barge is warped by the anchor winches to a position approximately 180-ft. from the blast area.

The barge has extensions which permit forward as well as lateral movement of the drill towers for sinking two or more parallel lines of drillings without having to move the barge.

CLASSIFIED ADVERTISEMENTS

Rates 4s. per line (minimum 8s.); Box Number 2s. extra; Rate for single column inch is £2 per inch. Prepayment of classified advertisements is requested. Orders should be sent to Advertisement Department, "The Dock and Harbour Authority," 19, Harcourt Street, London, W.1. Telephone: PAD 0077.

SHOTBLASTING—METAL SPRAYING—COATING Epikote, Araldite, P.T.F.E., P.T.F.C.E., Polythene, P.V.C., Neoprene and Hypalon coatings applied on SITE or at WORKS. LOYNE LIMITED, Margaret Street, Ashton-under-Lyne, Lancs. Tel. No. 4551/2/3.

FOR SALE

A QUANTITY of 4-ft. diameter Screw Moorings with 2¼-in. and 3-in. C.S. Stud Link connecting chains, shackles, etc. In good condition. Available Dar-es-Salaam. Full particulars from the Crown Agents, 4 Millbank, S.W.1. (Ref. O/Prod. 1971).

ABERDEEN HARBOUR

PRIESTMAN four-rope 140/120 cu. ft. Grab for sale. Designed for coal but suitable for other commodities. Weight empty 67-cwts. Unused since reconditioned by makers. Inspection by arrangement at Hull. Sealed offers marked "Priestman Grab" to be lodged with the undersigned not later than 17th September, 1960.

Harbour Office, ABERDEEN.
NORMAN R. BEATTIE
General Manager and Secretary.

10-in. ALLEN-THOMPSON, Dredger Pump, with spare Volute, 10-in. bends etc. Allen Diesel Engine 5. S.30. Steel Pontoon. Winch, Donkey Engine. All or separately. Quick sale, removal at Leisure. Etna Gravel. Snettisham 204.

CRANES: 15, 12½ and 5 ton Coles, 10 ton Lorain, 4 ton Tracked crane, 3 ton Hymobile, 2 ton Neals, Jones Super 22 and 8-cwt. Neals, B.G. Plant (Sales Agency) Ltd., Watlington, Oxon, Watlington 44.

WANTED

REQUIRED URGENTLY—Secondhand 2 and 3 cubic yard Whole Tine Grabs or similar for Rock dredging. Details and price, write Box DHA 737 L.P.E. Romano House, 399/401 Strand, London, W.C.2.

GOOD SECONDHAND Plant and Engineering Equipment, including Cranes, Forklift Trucks, Machine tools etc. Box No. 235, The Dock and Harbour Authority, 19 Harcourt Street, London W.1.

FOR SALE OR HIRE

FORKLIFT TRUCKS of every description for Sale or Hire including Kestrel Side Loading Carrier, 4,000-6,000 lb. Coventry Climax, Electric and Diesel, all types. Advice given on all your Mechanical Handling problems. B.G. Plant (Sales Agency) Ltd., Watlington, Oxon. Watlington 44.

TENDERS

DREDGING

The Newry Port and Harbour Trust invites enquiries from Dredging Contractors or Dredger Owners in connection with the dredging of 100,000 cu. yards of plastic boulder clay from Victoria Basin, Carlingford Lough, and disposal of same at sea 14 miles distant.
Offers for the execution of the work by contract or offers for the hire or sale of suitable plant will be considered.
Full details on request from the Harbour Engineer, Harbour Office, Newry, Co. Down, N.I.

SITUATIONS VACANT

IRELAND

VACANCY FOR HARBOUR ENGINEER
under Cork Harbour Commissioners

Salary: £1,700-£1,950. Max. age limit: 45 years, with extension in certain cases. Essential qualifications include at least 10 years' engineering experience, including experience of major marine, or analogous, works. Application forms, etc., from Secretary, Local Appointments Commission, 45 Upper O'Connell Street, Dublin. Latest time for receiving completed application forms: 5 p.m. on 5th September, 1960.

CLYDE NAVIGATION TRUST
HYDROGRAPHIC SURVEYOR

Applications are invited, from suitably qualified candidates, for the post of Hydrographic Surveyor on the staff of the Trust.
Applicants must have experience in taking soudings by lead line and by echo sounding machine. Good draughtmanship is essential and applicants should have the ability to plot soundings and to prepare dredging plans and estimates.
Applicants should state age, and full particulars of education training and experience.
The commencing salary will be £995, rising to £1,240 per annum. The successful applicant will be required to pass a medical examination and become a member of the Trustees' Superannuation Fund.
Applications, which will be treated in strictest confidence, should be lodged with the Engineer, Clyde Navigation Trust, 16 Robertson Street, Glasgow, C.2.